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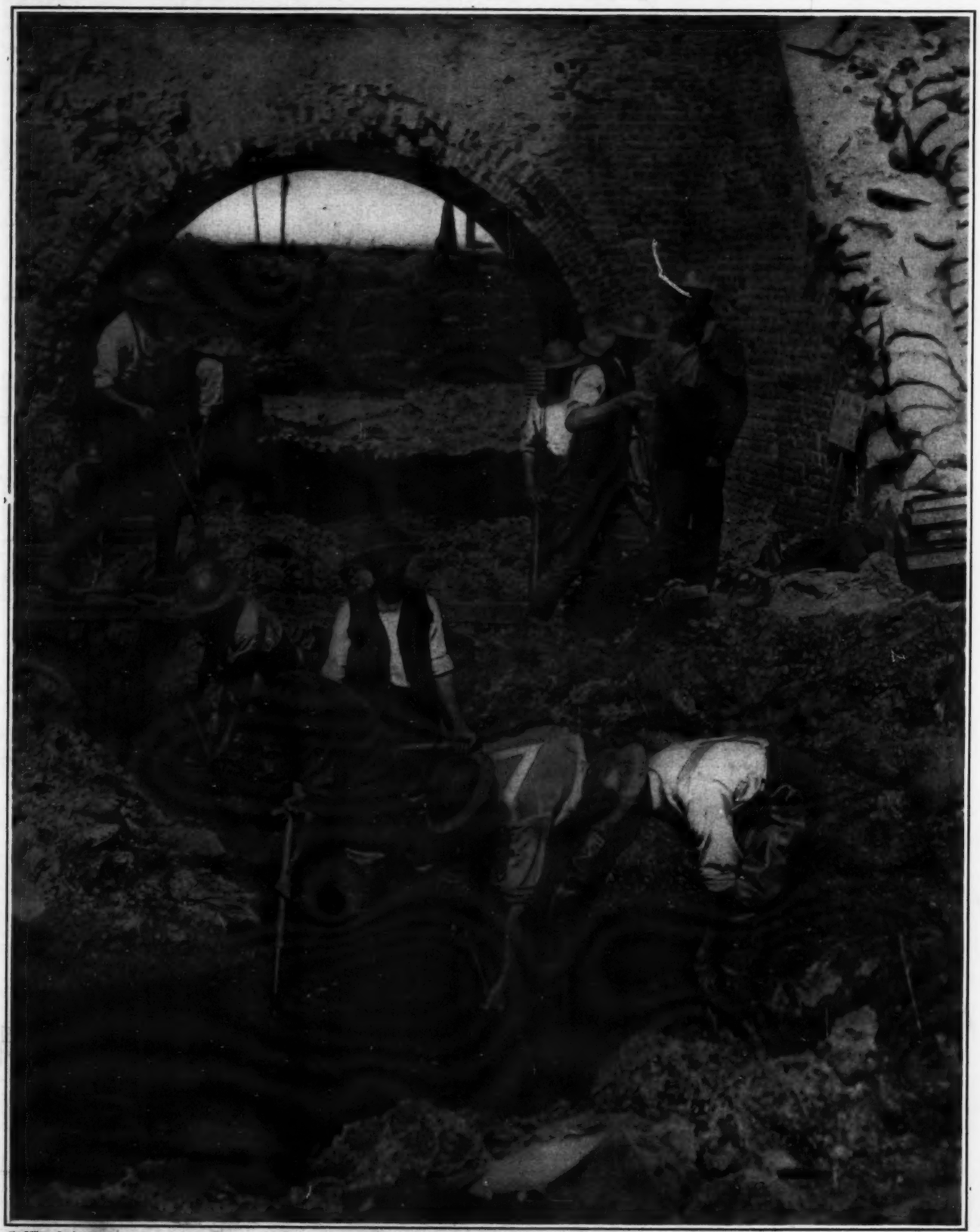


The Gillman Service.

A working squad of British troops renovating a water supply behind the lines

MAGIC BEHIND THE TRENCHES [See page 372]

Prehistoric Classification*

Steps in the Determination of the Age of Man

By W. J. Lewis Abbot, F. G. S., F. R. A. I.

THERE can be no doubt of the justification of the classification of the enthusiastic young prehistorian Lubbock, at the time of its introduction. When Prestwich invited him over to see the iron-stained weapons in the river-drift of the Somme, they were so obviously different from the "bleached" whitened cylindrical polished specimens found at or near the surface in this country, with which he had become familiar; and moreover they were indisputably associated with the bones of the extinct mammalia, in a gravel of great antiquity; whereas the polished bleached and fresh specimens were so closely associated with the existing order of things, that it was obvious the two were separated very widely from each other, in a manner as immediately to suggest an "older" and a "newer"—a palæolithic and a neloithic age. Further, the great difference between polished specimens of the surface and the more or less rudely chipped ones of the drift suggested the terms "polished" and "rough stone ages." But unfortunately the words "palæolithic" and "neolithic" were only extreme terms; palæolithic was confined to the river-drift specimens, and neolithic[1] was the equivalent of "polished" stone, but was vaguely made to include all specimens found at the surface. There was, however no "scientific frontier," between the two states, and with closer observation the "no man's land" grew into an ever-widening "buffer state." Soon everything found at or near the surface—especially if it had suffered any of these alterations which occur to flint on the surface of the earth—came to be regarded as neolithic. With this practice in operation, the hiatus became an impassable ocean, to bridge which many attempts were made. As time went on it became more and more apparent that archæolocially, geologically, and palæontologically the two were separated by a vast interval of time: a certain school then sprung up which suggested that the palæolithic and neolithic might be separated and bridged over by the glacial period (during which time it was claimed Britain was uninhabited). But the then existing predisposition towards the modernity of man would not allow the idea. (Comparatively recent as the glacial period might have been, it was altogether too long ago for man to have been here; and when implements were found in the Thames valley, to make man post-glacial it was asserted that the glacial deposits stopped on the Essex hills and at Finchley, and never entered what is now the Thames valley. It counted nothing that the glacial deposits at Finchley were not terminal moraines, but chalky boulder clay, and when this was even traced under Highgate into the Thames valley underlying redeposited London clay, the old prejudice was so strong that the old ideas still held the field! So firm was this hypothesis maintained that papers describing chalky boulder clay with northern erratics and fossils in the valley of the Thames were refused to be printed by the Societies! Since then the sections at the Admiralty and in the Lea valley have shown how wrong were these contentions.)

I think it was my old friend Westropp who first suggested to bridge over the gap, by the introduction of a "mesolithic" age, his classification was as follows:[2]

Barbarous	Palæolithic	Rough flints.
Hunting	Mesolithic	Flint flakes, flints chipped into shape.
Pastoral	Neolithic	Implements ground at edge, or all over, and polished
Agricultural	Bronze	Arrow- and spear-heads, swords and celts
State	Iron	Celts, spears, swords

Ingenious as this and its further subdivisions might have been in the light of the knowledge he possessed, this latter was altogether too small for so embracing a subject. The next, I think, to advocate a mesolithic age was my old colleague John Allen Brown[3]; most of his specimens, however, we should now regard as "surface palæoliths," of which some of us have large collections.

The question naturally asked was how it was that all the palæolithic implements were found in the gravels, and how they got there. I remember a hypothesis being advocated that man arrived here in a cold period, when the rivers were frozen over, and that he made airholes in the ice for the fish to come to, when they were speared, and through which the implements got lost in the rivers and mixed with the gravels. Even now there are many people who have not fully realized the chronological value of implements in a deposit. That they are fossils no one can deny, and they must be treated as such; but they differ greatly as chronometers when compared with the mollusca that may lie beside them. When one sees the delicate little double valves of the mollusca still unseparated, and a faunal assemblage which have a common habitat, we may be sure they are in their original home, and were contemporaneous with the deposit. As we examine the fauna of a particular river-valley at the different altitudes we are able to trace the history of the latter; whatever its depth may be we can see that the valley has been excavated in (say) pleistocene times; widely separated as its banks now are, time was when the valley was filled by the country rocks which at one time formed the surface of the earth, upon which man and beast lived; from the commencement of that excavation the stream has been carrying seaward the soluble and transportable materials, ever encroaching upon plateau and plain, cutting back subsequent and obsequent "land-grabbers," and constantly drawing into its vortex rocks, stones, and earth. But although its operations may have been extensive they were nevertheless limited, and vast areas of the surface have never been denuded of their surface materials. Naturally during the whole of this time the primæval hunters have camped beside its waters, and sat upon its banks and worked flints into implements which in many cases have been preserved practically as man left them. In other cases they have been whirled along in the waters and mixed with others belonging to long anterior ages. Sometimes an easier-wearing stratum has been encountered at some distance, and the stream has gone into the deeper channel and left the deposit (and perhaps the flaking floor) as a terrace, on the sides of the valley. The same thing, of course, occurs with the alteration of land altitudes, and base levels of erosion. I submit there are two very obvious facts that are not usually recognized.

First, that the area of old land surfaces that have not been destroyed by subaerial denudation in the process of valley formation is much greater than is sometimes realized. Secondly, that very generally implements are older—very often very much more so—than the deposit in which they are found. The first question that naturally suggests itself is, where are those uncaptured surface palæoliths? They must be on or near the surface still, and, having been subject to the same processes as the other flints associated with them, will be subject to the same set of surface changes. But the antiquity of anything found at the surface, especially if alteration processes have not been very operative, or if the specimens have become "whitened" (cretaised or porcellanized), is precluded by the ideas that have associated themselves with the term "palæolithic." It is therefore certain that the term palæolithic cannot be confined to the iron-stained (jasperized) specimens of the drift; nor can it be excluded from surface finds: consequently the terms palæolithic and neloithic, rough and polished stone ages, in the light of more recent discoveries are misleading, and should now be relegated to the pension list. It is true an attempt might be made to limit and define the term neolithic, but it would always be confused with its old equivalent, polished stone age (despite the fact that polished weapons belong to metal ages), or to things not found in an old river-drift. Further, so much more material from so many different sources has so enlarged our knowledge of late years, that we require a far more extensive and comprehensive scheme of classification. Probably the first real light that was thrown upon post-miocene succession came from the palæontological evidence. In their exhaustive researches on the pleistocene and holocene mollusca, Messrs. B. B. Woodward and A. S. Kennard have shown from time to time that the palæo-neolithic gap could be largely filled up by the mollusca of various sections, that the jump from the extinct to the wholly recent did not really exist, and that an orderly consecutive chronological series could be established from the pliocene to the recent. Then came the splendid work of Hinton on the vertebrates, telling of the same orderly succession. During recent years the science of lithoclasiology has developed, and this, in showing the natural history of the flintworker's art, establishes this same orderly sequence.

It did not require many years of either practical field work or philosophic reasoning to realize that the acheulian and chellian industries—the constituents of Lubbock's palæolithic period—did not represent man's first essays at flint working, and accordingly Gabriel de Mortilet proposed the term "eolithic" for certain flints which he considered bore evidence of man's work. But the idea of an intelligent being at so early a geological date as the deposits in which the flints were found received but little favor with many prehistorians. Later John Allen Brown reintroduced the term eolithic with more success for the worked flints from the S. E. plateau. It was when the writer was first showing him some of these

PREHISTORIC CLASSIFICATION

Geological.	Anthropic.	Older (former) archæological divisions.	With newer additions and correlations.	Lithoclasiology.	British localities.
Holocene.	Upper Neoanthropic.	Iron. Bronze (and copper).		Brachyclastic. Clinoclastic. Mesoclastic.	
			Last Hastingian.	Microclastic.	Hastings, Blackdown.
		Azilian.	Azilian.		Oban, Culbin Sands.
		U.	Kemsingian.		Kemsing.
		M.		Dolichoclastic.	
		L. Magdalinian.			
	Lower Neoanthropic.	U.		Clinoclastic.	
		L. Solutrian.	First Hastingian.	Microclastic.	Hastings Kitchen Middens.
		U.			
		M.			
Pleistocene.		L. Aurignacian.	Fairlightian.	Brachyclastic.	Fairlight, Hastings.
	Upper Palæanthropic.	U.	Cissburian.	Hemihedral.	Cissbury, Grimes Graves.
		M.	Ebbsfleetian.	Dolichoclastic.	Southfleet.
		L. Mousterian.	Preswichian.	Megaclastic.	,,
		U.	Oldburian.	Clinoclastic.	Ightham.
		M.			
		L. Acheulian.		Mesoclastic.	E., S.E., and S. River-valleys.
	Middle Palæanthropic.			Essentially Holohedral.	
		Chellian.		,,	,,
	Lower Palæanthropic.		Upper Ashian?	Holoclastic.	Hill Gravels.
Cromerian.			Strepyan?	Meroclastic.	,, ,,
Pliocene.	Protoanthropic.		Fawkhamian.	Heteroclastic.	Fawkham, Piltdown.
			Meridionalis Gravels.	Holoclastic.	Dewlish, Hastings, St. Leonards.
Norwich Crag. Red Crag.			Norwichian.	,,	Norwich, Whitlingham.
			Ipswichian.	,,	Ipswich, Thorington, etc.
			Mesvenian?	Meroclastic.	
			Mafflien?	,,	
			Rutelian?	,,	
Coralline Crag.			Lower Ashian.	Edge-worked.	N. and S. Downs.
			Stanstedian.	,,	Kent Plateau.
			Suttonian.		Sutton.
Miopliocene.					
Lenham Diestian.					

Science Progress.

[1] *Prehistoric Times*, 1872, p. 3.

[2] *Prehistoric Phases*, p xxiv.

[3] "Continuity of the Palæolithic and Neolithic Periods," *Jour. A. I.* vol. xxii. pp. 66–98.

plateau things that he exclaimed: "We have here the dawn of the stone age—the eolithic period." He was then reminded that it was already a preoccupied and presumptuous term; but he persisted in its application, and many have since followed in his lead.

Unfortunately the date of the plateau deposits in which the first evidence of intentional chipping was found has not been universally accepted; naturally the implements occur in beds which have generally been relaid several times. That the first of these are of pliocene age the writer has recently tried to show,[4] and fortunately most of his co-workers have accepted the assignment.

Within the last ten years an epoch-making series of worked flints have been found in East Anglia by Messrs. Reid, Moir, Clarke, Underwood, and others: from the positions in which these are found they appear to belong to three horizons:

III. Below the Norwich Crag (the norwichian).
II. Below the Red Crag (the ipswichian).
I. Below the White Crag (the suttonian).

There are so many facts pointing to their belonging to three separate age, which cannot be gone into here, that I think we may regard them as such. The suttonian would thus be pre-coralline, perhaps equivalent to the Lenham-Diestian of Kent, Surrey, and Sussex, antedating the invasion of the eastern counties by the Coralline Sea. We are then confronted with the questions: What is the age of the oldest implementiferous deposits on the plateau? Were they laid down by consequent streams which formed down the newly elevated Lenham-Diestian sea-bottom? and were the implements found in them of contemporary age, or were the worked flints surface-products of miocene times? The fact that in the deepest that has been opened—the stanstedian—freshly chipped specimens are found associated with very hard worn ones, rather perhaps points to the possibility of the oldest specimens dating to the close of the miocene age. I am, however, inclined to regard the plateau worked flints as post Lenham-Diestian.[5]

I would like to call special attention to several points raised in the *Proc. R. A. I.*, vol. xli. pp. 460-5. It is there shown, firstly, that an orderly sequence of flint-working can be established for the plateau worked flints. It is pointed out (p. 464) that many important factors may supervene: *inter alia* that implements of a given shape need not necessarily have had a monogenitic origin, that evolution of forms need not have followed on the same lines in different places, and that at any particular time all men would not have been in the same manipulative stage. If these factors did not hold good I fear that we should have to place the three older groups of the plateau below those of the sub-Crag.

In the same paper (*op. cit.*) a nomenclature for the various forms of flint-working is suggested. They are a lot of more or less ugly, loud-sounding words, but I submit they will improve upon acquantance, and to every student who has taken up the science of lithoclasiology they are indispensable: a glance at these distinctive features in a system of classification should convince one of their diagnostic value. Of course, when one speaks of "the age of mammals" or "the age of reptiles" one does not mean that every animal was a mammal in one case and a reptile in the other, but that they were the distinctive features of the respective ages; and similarly these various classes of methods of working are the distinctive features of the various ages, and as such have a high calssificatory value.

Up to this point we have not touched upon the palæontological side of the question; to this we will now turn. Quite early in the study of prehistoric man the famous Neanderthal skull was brought to light. Unfortunately its exact horizon was not known; but from its gorilloid characters, it was assumed upon the evolutionary hypothesis that it represented the lowliest and therefore the oldest type of human whose works had been discovered. The finding of this species, however, associated with a mousterian industry, and in stratigraphical superiority to the chellian and achuelian, revealed its existence at a much later date than was expected. Whatever might have been the date of its first appearance it was evident it had lasted down to post-acheulian times, and although lithoclasiologically absolutely distinct, it was faunistically associated with it without any break.

It is not so, however, in its relation to the superimposed aurignacean: here we have modern man separated by a prodigious fauna, of arctic habitat, and wearing the facies of both the past and the future.[6] The lithoclasiological break is just as pronounced. Obviously we have here a break so large that it must be very pronounced and conspicuous in any system of classification.

It cannot be supposed for a moment that every man living at this period was either morphologically or culturally mousterian, and we find here two and probably three well-marked cultural stages, and although the lower had a number of forms of implements which do not pass higher, it still had badly made bouchers, that associate it with the acheulian. The other two divisions have both connecting and separating forms, so that the three should be grouped in one division, say as a lower, middle and upper.

From the aurignacean upwards (with the exception of the solutrian, with its very fine clinoclastic work) there is no break, they belong to one great division; but we must not call it either palæolithic or neloithic: it is the division of the *new men* and we may therefore call it the neoanthropic: and the antecedent division, being that of the old men, the palæanthropic. The upper part of the neoanthropic will coincide with the holocene, the various cultures of which have not yet been thoroughly worked out, defined, or named, but the existence of some of them is indicated by their lithoclasiology. The lower part will lie in the pleistocene.

The palæanthropic will occupy the rest of the pleistocene, and extend into the cromerian pliocene.

All over this country and the continent there are to be found large quantities of meroclastic implements: whether they should all be assigned to one period it is difficult to say; the writer does not consider they should. They are just rough flints partly chipped. Generally (though not always) a simple rude point or cutting edge is put on, with little attempt at sharpening: those from some localities show very bold free-struck mesoclastic work, in others it is more mioclastic. Many years ago the writer first referred to these as archæoliths. They occur probably in the greatest numbers beneath the chellian, and in that position were called strepyan, by my old colleague Rutot, from being found at Strepy. Below these Rutot recognizes three other industries, mesvenian, mafflien, and rutelian: each of these industries finds a counterpart in this country, although not superimposed as Rutot found them in Belgium. Some of the mesvenian worked flints he has sent me are similar to the heteroclastic fawkhamian things of our plateau. They show round-hammer free-struck parallel flaking mixed with edge flipper-work. The flints from the two underlying industries are lithoclasiologically greatly inferior to the skilfully worked norwichian things, or even to the ipswichian, and are probably equivalent to the older pliocene plateau industries.

In piticanthropus and eoanthropus we are introduced to two very different kinds of simian characters, the one relating to the cranial vault, the conformation of the forehead, and browridges, and the others to a chinless ape-like jaw, all of which characters are protoanthropic. What other treasures await discovery we cannot say, but these two genera justify establishing another division —the protoanthropic. There can be no doubt that the anthropoidæa resorted to the use of clubs and stones long before they reached the large-brained stage of eoanthropus, and as we learn more of them we shall be able to subdivide this oldest division.

I submit that one part of the facts enumerated here calls for a revision of our classification, and the other suggests the lines upon which this should be based. One cannot for a moment claim that the classification as here set out is perfect and complete. It is only submitted as a basis, and it may be subject to whatever alterations and additions further and closer study may necessitate.

First, we have the geological horizons, or ages, commencing with the mio-pliocene Lenham-Diestian. Then the pliocene, pleistocene, and holocene periods repectively.

Next the anthropic divisions: protoanthropic, palæanthropic, and neoanthropic.

Of the first we are scarcely in possession of sufficient knowledge at the present to make subdivisions. There are several more points which must first be decided. But the industries are well marked. The second I submit can well be divided into a lower, middle, and upper. The lower to include the pre-chellian; the middle the chellian and acheulian, with their subdivisions; and the upper the mousterian with its sub-divisions.

The neoanthropic may naturally be divided into two; a lower and an upper, the line being drawn at the top of the passage industry, the azilian, just below the holocene.

Although a vast amount is known of the upper neoanthropic, a perfect sequence has yet to be worked out; certain well-marked lithoclasiological industries are indicated in the last column. Nothing but a vast amount of coöperative work will enable us to form a satisfactory classification. I feel convinced that the adoption of some such a one as is here offered will remove a vast amount of difficulties which now hamper alike the prehistorian and the palæontologist; and offer a good working basis in harmony with recent discoveries.

[4] "The Pliocene Deposits of S.-E. England," *Proc. P. S. E. Anglia*, vol. ii. part ii. pp. 175–94.
[5] "Pliocene Dep." *op. cit.*
[6] "The Ossiferous Fissures of the Valley of the Shode," *Q.J.G.S.* vol. 1. pp. 188–210, and vol. lv. 419–29; "Pleistocene Vertebrates," *Proc. S.E.U.S.S.* 1908, pp. 96-113; *Pal. Soc. Mono.* 1909.

Demagnetization of Iron

As the magnetic state of a piece of iron does not depend merely upon the field intensity to which the iron is being subjected, but also upon the previous magnetic history of the iron, it is necessary to destroy the effects of previous magnetization before proceeding to magnetic tests. The destruction is generally effected by the method of reversals, the magnetizing current being reversed many times while its intensity is gradually being decreased to zero. The demagnetization thus obtained is frequently very incomplete, and in the case of an iron ring, which is a closed magnetic circuit, there would in such an instance be no external evidence of the remnant magnetism. Studying the measurement of magnetic induction and magnetic permeability recently in the University of Michigan, Mr. A. Whitmore Smith (*Physical Review* May and September 1917) observed a very considerable time lag in the rise of the induction from the outside surface to the center of a bar which is being magnetized by a current sent through the solenoid surrounding the bar. Owing to the eddy currents which circulate in the iron in a direction opposite to that of the magnetizing current, the magnetic flux does not reach its full value until several seconds after the reversal of the magnetizing current. If, then, the magnetizing or the demagnetizing currents be reversed at too rapid a rate, there will be little effect upon a considerable portion of the interior of the iron. This consideration suggests demagnetization by current reversals at slow rates, and in his last paper on the demagnetization of iron Smith attempts to answer two question: in what state will a given process of demagnetization leave the iron? and in what manner will the B-H curve or the μ-H curve be affected by the method used for the previous demagnetization? Four different methods of demagnetization were tried. In the first method an iron ring, previously magnetized by a continuous current of 1.5 ampere, was subjected to an alternating current of 60 cycles, the intensity of which was slowly reduced from 1.5 ampere to 0.02 ampere; the hysteresis curve afterwards taken showed that three-fourths of the residual magnetization was not removed by this treatment. Better results were obtained with stronger alternating currents of 16 amperes, and also when the reduction in the intensity was effected by withdrawing a copper wire from a liquid rheostat containing a plate electrode; in this case the alternating current would be partially rectified. In the second method demagretization was tried simply by slowly reducing the magnetic field (continuous currents) to zero without any reversal; there was almost the same very imperfect demagnetization as in the first case. In the third method the continuous demagnetizing current was diminished and reversed by hand, with the aid of a mercury commutator, at the rate of one cycle per second; two-thirds of the magnetization were then left in the iron ring. All this was to be expected after the experiments on the serious time lag. Reversals were then made once every 10 seconds while the current intensity was reduced to zero in 12 steps, there being 10 reversals in each step. In this case the demagnetization was almost complete, the hysteresis curve being reduced to a very small loop about the origin. In the fourth method the current was reversed fewer times, but the intervals between the steps of the current reduction were made longer. The general conclusion drawn is that one reversal per second may be too rapid for demagnetization. The time required for the full reversal of the magnetic flux should be determined in each instance. This is done by closing the galvanometer key after reversing the magnetizing current and by noting the interval of t seconds, necessary in order that there should be no deflection; the reversal of the demagnetizing current should then not be faster than once in two t seconds. The t, it should be noted, is not constant for the same ring, being longer for regions of greater permeability.—*Engineering.*

Influence of the Fineness of Division of Pulverized Limestone on Crop Yield

An increase in the fineness of division of powdered limestone, added to soil, from 20- to 40-mesh, 60- to 80-mesh, 100- to 200-mesh, to finer than 200-mesh produces a proportional increase in the yield and total nitrogen content of crimson clover on several types of soil. The finer the division of the limestone the more rapid is the neutralization of the soil acidity and the greater the increase in the activity of the bacteriological processes of ammonification, nitrification, and nitrogen-fixation. In the case of barley, buckwheat, and rape, fine limestone without supplementary addition of nitrogen fertilizers, gives as high a yield as coarse limestone with an application of 600 lb. of ammonium sulphate per acre; 200-mesh limestone may be regarded as being as effective as burnt lime.—Note in the *Journal of the Society of Chemical Industry*, on an article by N. Kopeloff in *Soil. Science.*

Photo from the Gillman Service.

Engineers building a bridge for supply trains across a flooded area

Miles of old roads rebuilt and new ones constructed behind the lines

Magic Behind the Trenches

Technical Work as Important as Fighting

FEW Americans have any idea of the fight the working battalions of the allied armies, under direction of skilled military engineers, are waging to keep troops well supplied with raw materials, building roads, telegraph and telephone systems, constructing quarters for the soldiers, reconstructing and making liveable captured territory and in restoring and making again serviceable the cast off wreckage of war, the whole comprising an undertaking which the word marvelous but faintly describes.

The gallant deeds of the men who are fighting the great war are constantly brought to our attention, but comparatively little however is heard of the soldiers who don't fight but who work in the rear of the trenches, preparing by their plodding labor for the victory to come and remaking the wastes of recaptured land which through the utter ruthlessness of the enemy has been rendered quite uninhabitable for soldier and civilian alike. Yet this vast and vital military work now in progress, just back of the battleline in France, is of the greatest interest.

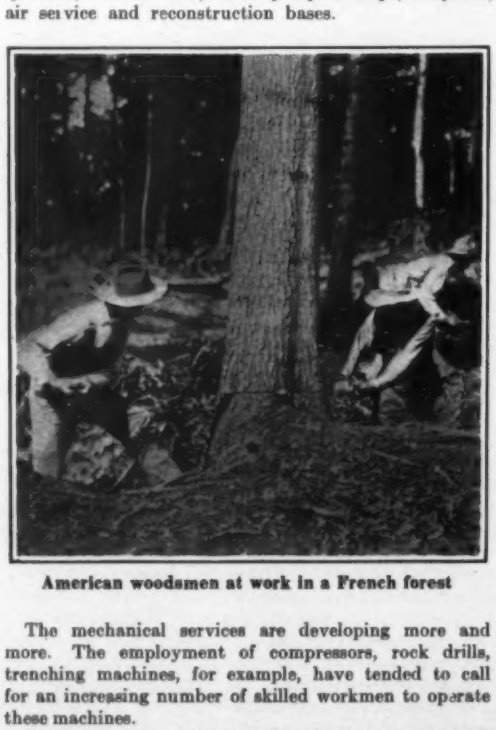
This war is a war of engineers and is fought with materials which are utilized and transported under the most difficult conditions, which is why it has been found necessary to organise certain sections of the armies on an industrial basis. One means of attaining this is to employ the enlisted men as far as possible in their ordinary civilian lines of work, or where their natural aptitudes will be developed. While this applies to the combatant forces, as well as to the troops in the rear, it is of particular importance to the latter who are daily proving of equal value to the soldiers in the trenches.

The modern battle is a problem of roads and a problem of transport. The railways and the roads may be compared to a great system of arteries for the army. As the occupied territory expands, a constant growth of the network of railways appear in the zone of the armies, necessary for the rapid provisioning of the troops of all arms in food, supplies and munitions; for their removal from one point of the line to another; for the entry into action of the heavy artillery mounted on trucks and other units. It follows that the maintenance of these lines, and the construction of new extensions in captured territory, daily becomes of greater importance on account of the constant augmentation of traffic. In both cases the employment of a large and highly trained personnel is required for the laying of tracks, for the repair shops, drivers and conductors, to handle construction and reconstruction material and accessories.

The applications of means of transport to the front are numerous and varied. There have been adopted progressively all of the systems which are known to the engineer; narrow gage railways have become of very common usage. Cableways and telepherage systems have given extraordinarily valuable service on the front. One installation of this kind has permitted an economy of 600 mules a day at one point on the French front.

The automobile, with its heavy trucks, and with its tractors, plays a role which day by day becomes more important, and the thousands of drivers and mechanicians and repairmen have, little by little, come to constitute a more and more important organism of the arm behind the lines.

The great distribution systems for electric light and power in the zone of the armies likewise compel attention. Among the users of these networks are the head quarters, cantonments, artillery repair shops, hospitals, air service and reconstruction bases.



American woodsmen at work in a French forest

The mechanical services are developing more and more. The employment of compressors, rock drills, trenching machines, for example, have tended to call for an increasing number of skilled workmen to operate these machines.

In the ever expanding zone gradually evacuated by the enemy an immense amount of restoration has already been undertaken calling for highly skilled laboring battalions to undertake the seemingly hopeless herculean tasks of building or restoring roads in the wastes of what had a few days before been "no man's land." Flooded land newly recaptured from the Boche has also to be rapidly drained before it can be made available and bridges rebuilt over the streams and creeks.

Then comes the construction or reconstruction as the case may be, of great shelters for the troops, which call for quite as skilled men as the forces which construct the subways in our cities. In fact even more skill is often demanded, as the men who build these places only are allowed a few days to complete their great work instead of the weeks, months and even years our subways seemingly require, and in this limited time they must not only blast and excavate but timber and construct vast concrete works and other shelters under the most trying, difficult and dangerous circumstances and not leave their task until the shelters are complete.

If given time one of the things the enemy never overlooks before abandoning a territory is the destruction of the water supply, yet if the country is to be again made habitable good drinking water is vitally necessary so the first task of the working battalions of our army and its allies is to give its attention to the repairing and restoring of an adequate water supply. Next in importance to this restoration comes the question of the establishment of communication between the troops under fire, who have taken possession of the captured land, the rebuilding therefore of the telegraphic and telephone service naturally occupies a place of the greatest importance in the work of the plodders behind the lines as it constitutes the nervous system of the battle.

No sooner therefore do the allied armies take over a tract of wasted land than every means known to science and mechanics is utilized to arrive at a sure and rapid liaison between the various army elements. Fortunately apparatus and methods have been developed to an extraordinary degree, thanks to the impulse given by the militarized engineer, who has attacked this arduous problem successfully.

Naturally to get desired results it has been found necessary to obtain the highest efficiency in the battalions working like busy bees behind the lines, to organize them into special units or distinct military organizations, autonomous and perfectly complete, and each known by its distinctive title, such as "Forestry service." "Water supply service," "Roads service," "Railways service," "Electrical service," and "Mechanical service."

The art of the engineer also is exercised in the technical organization. It seems strange, although it is really logical enough, to find consulting engineers taking their

place in the General Staff along with the tacticians. Technical and industrial problems arising for solution become daily more numerous as the armies progress, and more closely allied with the military operations.

Other reconstruction work back of the lines of almost equal importance to the above is that of remaking by modern magic the cast-off wreckage of war.

Few persons in this country have any idea of the tremendous restoration of the wreckage of battle that is going on behind the allied lines in France, work that is saving millions of dollars a year; and yet there are few things in the conduct of the war more wonderful.

To the military workers in charge of this hive of industry is brought all the jetsam of battle, from a broken rifle or bicycle to tattered tunics and derelict shoes and boots—all to be renovated and made serviceable again.

There are shed after shed piled to the roof with discarded shoes, most of them in such a condition that is deemed nothing short of a miracle could restore them. In former years they would all have been consigned to the rubbish heap as worthless. Not so now.

Stage after stage shoes broken in war are again, by military workers, quickly converted into boots, soft and strong. First they are soaked in a mixture which renders the leather pliable as ever. They are then scrubbed and rubbed and patched and soles or heels put on where required. Over 2,000 pairs are renovated in this way every day.

In other field workshops khaki uniforms tattered, torn and mud soiled are made good as new. After passing through a disinfecting bath they are carefully dried and then taken in hand by a small army of tailors who with wonderful cleverness and ingenuity remake them. Then they are returned to the army ready for service again.

There are also hospitals for wounded cannon, machine guns and rifles where furnaces blaze night and day, and the vulcans work amid a thunderous crash and roar. Here are broken rifles to which a new lease of life is given. The butts and wooden parts are repaired or renewed; the damaged metal parts are replaced by new ones, rusty barrels are freshened up, and so on, and in a day or two these heaps of old iron are, for all practical purposes, so many brand new rifles doing deadly execution in the trenches.

Close by you will see thousands of broken bicycles—so much scrap iron to look at, beyond all hope of repair. Here again the magician is at work. With amazing skill and rapidity the damage is repaired, broken parts are replaced and the machines, restored to usefulness again, are returned to their units.

The Fish Louse: *Argulus Foliaceus L.**

By René Merle

We have received repeated requests from some of our subscribers for information as to the remedy for the fish louse which invades their sheets of water, destroying their carp and their *salmonides*. The following article is a response to these requests.

The fish louse, or carp louse, whose scientific name is *Argulus foliaceus L.* is a small crustacean belonging to the group of the *branchiurae* which sometimes pullulate in sluggish waters, and are then found, sometimes in very large numbers, on the skin of fishes. Its most frequent victims are carp, less often tench and bream, sometimes trout.

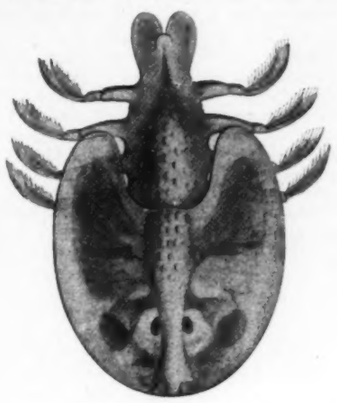
It has an oval form and its size varies from 1 to 5 millimeters according to the age and sex.

The back resembles a shield or "buckler" in shape, while its ventral surface presents numerous appendices. It is as thin as a sheet of paper and appears upon the fish under the aspect of a yellowish green spot. It fastens itself rapidly and firmly by means of two powerful "suckers" situated below the eyes, and by two hooks borne upon its anterior antennae. The mouth is provided with a proboscio of fine-toothed mandibles and exceedingly sharp edged jaws. It is surmounted by a keen retractile stylet, pierced by a channel wherein flows the venom of the dijective glands. The alimentary canal is widely ramified and its numerous diverticles permit the storing of a sufficient quantity of nourishment to enable the argule to go without eating easily for more than a week. Thus armed, the fish louse has all the needful tools for making a good livelihood and his life is not as monotonous as it would seem. Sometimes he hooks onto a fish, especially where the skin is delicate, chiefly at the junction of the fins, which the fish cannot scrape against water plants or on the bottom. Sometimes, having fed abundantly, he quits his prey and swims away, either for moulting or for reproductive purposes. These duties accomplished he seeks a new host.

Generally the *argulus* are present in numbers too small to do much damage. But, at times, when the conditions are favorable, they increase rapidly, and the fish, pricked and sucked from by hundreds of the lice become anemic and ulcerated and finally die.

The males are smaller than the females and swim more rapidly; they are also much less numerous; they can be recognized by two black points situated at the base of the abdomen. The females lay their eggs, numbering hundreds and glue them to stones and water plants. About a month later the larvae are hatched, already provided with hooks, but without suckers. A few days later the first moult takes place, soon followed by others, and six weeks later the *argulus* begin to reproduce themselves. Since each female usually lays three times during the summer it is obvious how rapidly they can infest a sheet of water and become dangerous to fish breeding.

But generally this does not occur. Cold water arrests their multiplication, small surface fish devour a large number of the larvae, and finally healthy fish, "seem to be no more incommoded by them than a dog by his fleas," according to Wilson, a naturalist in the American



Bureau of Fisheries. But when the water warms up for a considerable period of time, when the fishes languish and become less resistant, the *argulus* soon become a veritable calamity.

Heat, in fact, provokes a rapid increase of the parasites at the same time that it enfeebles the host. The latter soon becomes covered with the lice; his fins are gnawed his tail slashed, his skin becomes punctured, torn, bleeding. The pond is soon covered with corpses, and the evil grows worse and worse. The lice quit their victim as soon as it is dead and precipitate themselves upon another. Sometimes sheets of water are entirely depopulated in a few days.

Prophylactic measures against this brood are easier to take than therapeutic ones. Aquatic plants, furnishing shade, prevent the water from becoming heated, and an abundance of surface fish destroys great numbers of the *argulus* and arrests their increase.

Deep bodies of water are always much less infested, as also those which are fed by springs at the bottom. The water supply can also be filtered by means of a sand bar.

When the *argulus* have already made their apperance remedial measures are much less efficacious. Branches of trees should be thrown into the water against which the fish can scrape themselves to remove their parasites. An especially excellent means of ridding a pond of such invasion is to take advantage of the winter cold to drain the pond and leave it dry for some time. But as in so many other cases prevention is better than cure.

* La Nature (Paris).

Magnetization by Rotation

The idea that a rotating magnet should behave like a gyrostat if the ampere currents consist in the motion of actual matter is an old one, and Maxwell constructed an apparatus for testing it as early as 1861. The suggestion does not imply, however, that the magnetization generated by rotation of a magnet should simply be proportional to the angular velocity. For if that were so, laboratory experiments on small magnets at a few revolutions per second should give rise to magnetic forces vastly greater than the terrestrial magnetism and greater than any magnetic forces obtainable by other means. Professor A. Schuster discussed these problems, which had long been occupying him, in his presidential address to the Physical Society in 1912, with special regard to Causes of Terrestrial Magnetism. Since 1909 Prof. S. J. Barnett, of the Ohio State University, has been experimentally investigating the subject, and he has given an account of his researches in two long papers published in *The Physical Review* of October, 1915, vol. vi. pages 239 to 270, and of July, 1917, vol. x. pages 7 to 21. Like Schuster and Langevin, he starts from the assumption that rotation only sets up a magnetic force, which may or may not produce magnetization, and will only do so if the substance be magnetic and therefore constituted of atomic or molecular orbital systems with individual magnetic moments fixed in magnitude. Barnett's orbital systems consist of a number of electrons revolving at constant average velocity in fixed orbits about an oppositely-charged nucleus, and he further considers that the electrons would preponderantly, if not altogether, be negative, as is generally assumed for various reasons. On the electron theory he then shows that a body of any substance set into rotation becomes, by a sort of molecular gyroscopic process, the seat of a uniform intrinsic magnetic intensity parallel to the axis of rotation and proportional to the angular velocity, the intensity being directed—like the magnetization of the earth and of the sun—oppositely to the intensity which would be produced by an electric current flowing round the body in the sense of the rotation. The intrinsic intensity per unit angular velocity would be $H/n = 4\pi m/e = -7.1 \times 10^{-7}$ gauss, where H is the intensity and n the number of revolutions per second, and m and e are mass and charge of the negative electron. Barnett also discusses the theory of the converse effect, rotation caused by magnetization, which was established by A. Einstein and W. J. de Haas in their "Demonstration of Ampere Currents" (see *Engineering*, August 27, 1915, page 224), and this has since been further confirmed by de Haas in a communication on "Moment of Momentum existing in a Magnet," presented to the Amsterdam Academy, 1916. In his experiments Barnett made use of steel rods, from 2 cm. to 7 cm, in diameter, nearly a metre in length, turned about their longitudinal axes at from 20 revolutions to 90 revolutions (generally about 50 revolutions) per second by an electric motor. In each case two similar rods were observed, the one rotating, the other stationary and very elaborate precautions were adopted to reduce the effects of the numerous sources of error; there was always *e.g.*, a slight fluxmeter deflection independent of the direction of rotation. The recent experiments were made with the aid of a magnetometer—not a fluxmeter—on two cold-rolled steel rods about 30 cm. long, 2 cm. or 3 cm. in diameter, and on rods of nickel and cobalt of similar dimensions. Again the results were not very concordant. But while the former series of experiments had yielded the average value $H/n = -3 \times 10^{-7}$ gauss per revolution per minute, the new series yielded the coefficient 5 instead of 3, against the theoretical value —7.1. In this theoretical estimate it is assumed that only the negative electrons are concerned in the phenomenon; if the positive electrons also had a part the experimental value should be smaller than the theoretical. A smaller value has been found. Barnett considers, however, that the actually observed effect is all due to negative electrons, and that it is too small owing to experimental difficulties. That there is no such effect in non-magnetic metals had already been shown by Lebedew.—*Engineering.*

Some New Paper-making Materials

Ecdeicolea monostachya is a rush-like plant found only in Western Australia; the stems or so-called "leaves" are erect, rigid, rather slender, and vary in length from 2 to 5 feet. Treated in the same way as esparto grass (Oran) they gave approximately the same yield of pulp, 44 per cent on the air-dry material, but the pulp was inferior in appearance, darker, and more difficult to bleach; it was also contaminated with yellow specks of a wax or resin, which could be removed by a more severe treatment, at the expense, however, of the yield of cellulose. This plant is regarded as a practicable material for the manufacture of paper pulp.

Neoboutonia macrocalyx is a tree growing to a height of 50–60 feet and a diameter of 15-20 inches in the East African Protectorate. It is extremely abundant and grows rapidly. The timber is of little value on account of its "woolly" nature, being very soft and light. Treated by the soda process under the same conditions as spruce, it yielded 46 per cent of pulp of good quality as compared with 42 per cent from spruce wood. The fibres are shorter than those of spruce, but the pulp bleaches well.

Brachystegia Randii is a tree which forms extensive forests in Mashonaland. The timber is of little value, though it is used for hut building. Ribbons of the inner bark have been examined, and a cordage fibre of inferior quality prepared, but being much interlaced it was not suitable for spinning. On digestion with 20 per cent of caustic soda the bark yielded 33-34 per cent of pulp of a dark color, giving a strong brown paper. The pulp bleached easily and yielded a white opaque paper of good quality. The bark might be considered as a substitute for *Adansonia* bark but of lower commercial value from the point of view of yield; the economic difficulties of its transport from Rhodesia, however, would be considerable.—Note in *Journal of the Society of Chemical Industry* on an article in *Bull. Imp. Inst.*

Chemical Laboratory Porcelain *

By Henry Watkin

THE first attempts to make porcelain in Europe were undoubtedly in imitation of the Chinese porcelain imported into Europe by the Dutch, English and French East India Companies about 1673.

Its beautiful whiteness, its thinness, its translucency, its close vitreous fracture, apart from and also in conjunction with its decoration, at once appealed to and obtained the admiration and emulation of the Europeans.

The story of the struggle in the attempt to reproduce it is not within the scope of this paper, but suffice it to say, that it was accomplished in Germany by Bottcher about 1706-1718, and in England by Cookworthy of Plymouth about 1767.

The one factory continued for the reason that not only were the products excellent, but the financial success was not the main object, while the other had to bear its own losses and though there was considerable promise of success, the financial aspect of the undertaking was a complete failure. It is well, then, at the outset to note that we do not owe the origin of the porcelain to the continental potters but to the Chinese.

Chinese porcelain being at that time the only translucent pottery in existence, there can be no wonder about the admiration it called forth.

It cannot be surprising, then, that the English potters were very anxious to produce such a body, and if that object could be obtained, the means by which it was attained were secondary matters, and we find that instead of continuing the manufacture of hard paste porcelain, they produced, about the end of the 18th century, (1) a beautiful white earthenware which for generations secured the market of the world, and made it possible to replace almost all other pottery for domestic purposes. (2) A translucent white porcelain similar to the Chinese, by the use of other materials and methods, equally beautiful, which for over a century has held its own amongst all other porcelain productions, and which is generally known as Bone China.

The ceramic production of the world as regards their bodies or paste, apart altogether from decorative effects, vary from goods made from the coarsest to the finest clays, through almost every variety of texture by admixture of the natural clay with other materials, such as sand, flint, barytes, felspathic rock, etc. From these materials ware produced at one end of the scale the cinerary urns of our great ancestors, and at the other end, the excellent hard paste porcelain which we are considering today.

The marvellous difference in the productions of the various peoples of the world may probably be explained by the general assertion that the potters have from the very earliest times worked with the materials they had at hand. The cinerary urns of the Ancient Britons were made from natural clays.

The Staffordshire potters used, at first, natural clays, found cropping up simultaneously with the coal, and subsequently improved the color and texture of the product by the addition of, first, fire clay, then Devon and Cornish clay and calcined flint. Messrs. Eler Bros. used the read marl of the Burslem district for their fine red ware. Bottcher of Germany at first made red ware from local clays, etc., and afterwards porcelain from the white clays or kaolin, and pegmatite.

The Chinese for centuries had been working with their natural materials, kaolin and petuntze, and from these produced their fine porcelain. Some of these various clays naturally required a much greater heat than others to produce hard vitreous bodies.

These varying conditions with regard to materials to the hand of the potter, when means of communication were so restricted, necessarily involved very varied methods of manufacturer. The materials differing so essentially from each other naturally required very varying degrees of heat necessary to bring to maturity.

The kaolin and petuntze used by the Chinese would require a much higher temperature to mature than the clays, etc., used in other countries at the time. The exact temperature would not be found at once, and in working out the same an observant potter could not fail to notice the changes taking place in the fired material in regard to vitrification, translucency, and finally distortion at the various temperatures. Thus in all probability without any more scientific knowledge whatever than careful observation, the fine product of that time would be produced which even now (centuries later) is the object of our research.

While the Chinese were for centuries making the most suitable material in the world for chemical laboratory ware, they had no use for such, and consequently did not make it. It was only with the advance of scientific chemical knowledge in Europe, that the need was felt for the various porcelain accessories that were then called into use.

It is not surprising, therefore, that Germany and France having continued making the Chinese type of porcelain, should have applied themselves to this particular demand, and while the English porcelain manufacturers were busy on their own particular class of porcelains they should have almost entirely secured the trade of the world in this branch.

With the cessation of the importation of Continental porcelain into this country, came the call to the English potter, and, as might have been expected, it was not every manufacturer that would listen to the call, neither was it needful that they should.

There was no very tempting offer of any lucrative opening in the new business, and a potter must be more tempted by patriotism to his country, and a desire to meet its needs, than by immediate prospective financial success.

DEFINITION OF PORCELAIN

It is almost impossible to give a definition of chemical porcelain which could generally be regarded as entirely satisfactory. When first porcelain was introduced into Europe, its translucency was sufficient to differentiate it from all other ceramic productions of that period.

We have seen in the attempts to produce a similar porcelain in Great Britain and the Continent other kinds of translucent pottery were discovered, which are known under other names, such as bone china, soft paste porcelain, etc., the former of which for over a century has held its own amongst the finest productions of the world.

It is quite clear then, that what was once the predominant and characteristic definition of Chinese and Continental hard paste porcelain is so no longer, and translucency alone could never be regarded as the guarantee of chemical porcelain. Translucency is only one of the properties of porcelain and that rather of beauty than utility, as evidenced by the fact that so much of the beautiful translucent porcelain of England has been found useless for the purposes we have in our minds at the moment. To understand the nature of the porcelain required for this purpose needs a clear conception of the uses to which it is to be applied and consequently the qualities required of it.

PROPERTIES OF PORCELAIN

In order to decide on the possibilities of the manufacture and the manner of procedure, it was desirable to consider the relative importance of the qualities demanded.

These vary very considerably in their degree of importance, and I am inclined to place them in the following order.

1. The first and foremost quality, I submit, is that of *resistance to very sudden changes of temperature* of as wide a range of heat as possible without cracking during the operation or at its close on cooling. The greater the range of difference in the temperature the porcelain will allow itself to be subjected to in the quickest time without cracking or breaking, the better and more suitable the porcelain.

2. *The resistance of the glaze to the action of chemical reagents* so that the solution may not take up additional weight by dissolving portions of the glaze and thus leading to false estimations in chemical analysis.

3. *The colour of the porcelain* should be white or cream although for special purposes green, blue, or black is sometimes used.

4. *Fusing point.*—The glaze should resist fusion at temperatures well above that at which the articles are generally used.

5. *The weight of the material.*—This is not a very important matter, but it is inadvisable to put excessive weights upon delicate balances, and secondly, liability to cracking increases considerably with the thickness of the material.

6. *Composition.*—The materials which enter into the composition of a porcelain for chemical laboratory purposes appears to matter very little, providing the qualities required for the purpose are complied with; *e. g.*, we are all quite well aware of the fact that one of the materials entering into all porcelains, namely, silica, can without any other additions be made by fusion to fulfil perfectly all the conditions required, unless the material being tested reacts with the silica itself at the temperature.

7. *Translucency.*—This appears to be a quality which is not absolutely necessary for the purpose and may be dispensed with entirely without detriment to the article, provided the other qualities are correct. A piece of very translucent pottery may, for the purposes we are considering, be much worse than a piece of very feeble translucency.

The question now becomes, is it necessary or compulsory to confine ourselves to the methods of either the Chinese or Continental manufacturers? Are these the only ones open to us?

We have seen that it was possible to use materials in such proportions that the firing temperature became a necessity on account of the proportions of fusible to infusible materials present, which needed the high temperature in order to give to it one of its qualities which is not a necessity.

Hence with similar or other materials, it was quite feasible to suppose that the same end could be attained by regulating the length of time the glaze is allowed to remain in a fusing condition on the ware.

MATERIALS

The materials generally used in hard paste porcelain bodies are ball clay, china clay or kaolin, quartz or flint, felspar, Cornish stone, pegmatite, sometimes a very small proportion of lime, and sometimes ground broken porcelain.

MANUFACTURE

The materials are weighed out in their proportions, and by the usual blunging operations are intimately mixed by using a large excess of water. The mixture is passed over sieves to abstract any coarsely ground materials, and passed through a trough containing magnets to eliminate any particles of iron either present in the clay as pyrites or other magnetic forms, also from the wearing of the bearings of the machinery. It is then passed through the filter presses from which, when the excess of water has been removed, it is taken as oblong sheets of plastic clay approximately 6 feet long by 2 feet wide by ¾ inch thick. These sheets are then rolled up for convenience of removal and passed through a pug mill where the clay is made homogeneous, the air driven out, and extruded as a continuous mass of plastic clay of a square section about 6 inches and cut off in convenient lengths. It is now ready for use for most purposes, but sometimes is still urther improved by wedging or by rolling on machines by the French method.

CASTING

This consists of pouring the slip or body mixture into moulds made of plaster of Paris, and allowing it to remain there for a definite period, when the surplus is emptied out and the article is dried and removed from the mould. The thickness depends upon the length of time the slip is left in the mould. There is always a liability to get differences in weight and thickness which may account for cracking for the following reasons.

First.—The articles may be made so thin that although they are on that account able to conduct or disperse the heat quickly when suddenly heated or cooled there is not sufficient mechanical strength to withstand the strain.

Second.—In making the article thick enough to withstand the mechanical strain, there is a great danger of making it so thick that the porcelain is cracked owing to unequal expansion or contraction.

When the articles are made they are placed in fire-clay receptacles called saggars, which are arranged one upon another in the ovens for firing. The matter of placing is of very great importance and requires great experience and care. When the oven is filled it is either fired according to the method adopted by the hard paste manufacturer whose work we are considering, or by the English method.

The Chinese and Continental manufacturers invariably give their clay ware an easy or low temperature treatment in the first firing, which not only facilitates the subsequent dipping process, but also gives the glaze when fusing upon the surface of the biscuit during the second fire, a better chance of assimilating itself to the body. This can be clearly seen by the absence of a sharp dividing line between the glaze and the body, which is often seen in earthenware and china. The English manufacturer, on the contrary, invariably gives the highest degree of temperature during the first fire.

In some instances where the article is sufficiently strong to be dipped into the glaze without collapsing and losing its form, it is fired both for body and glaze at the first and only fire, but this procedure is rather restricted in its extent by the nature of the articles, and generally it is preferable to submit the goods to the easy fire first, *e. g.*, it would not be found an easy process to dip evaporating basins in the clay state without collapsing. The first firing, except in the case last mentioned, viz., the clay dipped goods, produces what is known as the biscuit or once-fired goods, the surface of which is rough and without glaze.

This ware is then emptied from the saggars, carefully inspected, faulty goods eliminated, brushed to remove any particles of sand, and passed on to be dipped, which means the glazing process, which consists of dipping the articles in a mixture of compound silicates of alumina, potash, calcium, etc., etc., ground to a fine powder and

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held in suspension in water, or in ground felspar and lime as practised by the Chinese.

The glaze when dry is then removed from such parts as needful to prevent the pieces sticking to each other during the fusion of the glaze in the next or second firing operation. Another method of separation is by the use of stilts and spurs of various designs. To keep the goods true in form in the second firing is one of the most difficult problems of the manufacturer of chemical porcelain.

The firing of the oven is usually taken to a higher temperature than that of the first or biscuit firing, and takes about 50/60 hours or more to complete.

The judgment of the temperature reached during the operation is effected by various pyrometers, including electrical pyrometers, radiator pyrometrs, Wedgwood pyrometers, pyro cones, recorders, etc., etc.

When fired there is still another operation, namely, that of removing any stray bits of sand, saggar dirt, etc., etc., adhering to the glaze, which is accomplished very much on the principle of the glass cutters' operation, who no doubt introduced it to the potters' industry.

The last and final operation is selection and packing.

TESTING

The method of testing the suitability of a porcelain for chemical purposes does not appear to be standardized. Samples sent to one analyst may be treated in quite a different manner to those sent to another.

The three essential qualities that need to be tested for are as follows:

1. The resistance to sudden changes of temperature without cracking.
2. The resistance of the glaze to the action of chemical reagents.
3. The fusing point of the glaze.

The first of these (the resistance to sudden changes of of temperature without cracking) appears to be the most important, judged from the number of tests applied to this particular quality by the German chemists.

Out of nine tests applied to the Haldenwanger porcelain, seven were those applied to this quality, while two only were applied to the resistance of the glaze to the action of chemical reagents.

GERMAN. SEVEN METHODS OF TESTING

1. Heated repeatedly for two days on a Bunsen burner and allowed to cool.
2. Exposed to great heat and then suddenly placed on a cold metal plate.
3. Immersed in water for six days and then heated until glowing.
4. Made red hot on a burning gas flame and suddenly placed on a cold metal plate.
5. Made red hot, gas turned off, and immediately exposed to a blast of cold air.
6. Heated up to melting point to Seger cone 010 = 950° C. in a muffle furnace, sustained at that for 10 minutes, then quickly taken out and placed on a cold stone.
7. Same experiment as last, taken up to melting point to Seger cone 1 = 1150° C.

ENGLISH. FOUR METHODS OF TESTING

1. Crucible filled with wax and heated until the temperature rose to 130° C., then allowed to cool to 125°, to insure that the outer layers of the porcelain did not exceed this temperature.
2. Crucible plunged into cold water at 15° C., and the same experiment repeated at 175°, 200°, 225° and 250° C.
3. Crucible placed in a muffle heated to about 900° C. and when thoroughly heated, removed and allowed to cool in the air.
4. Crucible plunged into a furnace at dull red heat, approx. 550° C., and allowed to cool in the air.

THE RESISTANCE OF GLAZE TO THE ACTION OF CHEMICAL REAGENTS

The action of water on the vessels is determined in the manner usually employed for glass ware, viz.: Very carefully prepared distilled water is placed in the vessels, which are then heated to 80° C. for three hours. The action of the water is determined with iodoeosin, equal volumes of water being used for each dish, and the same volumes equally distributed between three crucibles. The contents after treatment with iodoeosin are placed in the series of comparison cylinders to observe the difference in alkalinity. The volume of iodoeosin solution required to restore the color determines the amount of acid or alkali dissolved from the porcelain.

A second test is made as before but the action is continued for 6 hours at 100° C.

ACTION OF ALKALI

The dishes are heated in a steam oven, cooled in a desiccator and weighed. Fifty cubic centimetres of caustic soda solution (40 grams per liter), is placed into each of the dishes, and another 16⅔ Cc. divided equally between the three crucibles. After heating in a perfectly closed oven so that no liquid is evaporated, for three hours at 80 degrees, the dishes are removed and cleaned, then heated in a steam oven, cooled in a desiccator and weighed, the difference in weight giving the amount of silica or other materials dissolved.

The same method as the foregoing is adopted but with caustic potash for five hours at 100° C. instead of three hours at 80 degrees.

ACTION OF SULPHURIC ACID

In this test 5 Cc. of normal sulphuric acid (49 grams per liter), is placed in each crucible, and carefully evaporated, finally volatilizing the sulphuric acid by heating over a Bunsen burner. The crucible is then weighed and any difference in the weight gives the amount of loss sustained by the crucible.

ACTION OF NITRIC ACID

The action of nitric acid on the crucibles is tested for five hours at 100° C.

RECENT OUTPUT

More than 150 years' experience of the manufacture of hard paste porcelain at the State supported Royal Factory of Berlin, the experience of which was placed at the disposal of the porcelain trade of Germany, gave it a tremendous advantage over the English manufacturer. It was therefore, no light task for an English manufacturer, minus that experience, under entirely different conditions, with all the models and moulds to prepare, to attempt the task. Some three or four English manufacturers, however, have attempted the same with very considerable success.

While I cannot speak with any degree of confidence in relation to the manufacture or supply of other factories than our own, I think I may safety say that there is now no very serious occasion to go abroad for any of the chemical porcelain accessories needed in this country.

War-Time Smuggling

Do those grumblers among neutral nations who deplore the continuance of the war ever pause to reflect on the manner in which many of their countrymen are helping to prolong it? Unfortunately it is exceedingly difficult to impose a more than partial control on the traffic in contraband, for so great is the temptation held out by hungry Germans to needy neutrals that these will run almost any risk and exercise incredible ingenuity in evading it. In spite of the good faith of the S. S. S. (Société Suisse de Surveillance), the vigilance of the frontier gendarmerie or military police, and the care taken by the Legations and Consulates of the Entente countries to keep the authorities informed of what is going on under their noses, the quantity of metals, rubber, pepper, cotton, wine and silk that is finding its way into Germany even in this fourth winter of war is disconcerting to those whom circumstances compel to look on, helpless to arrest it.

As for the small smuggler, he, or more often she, is amusing rather than serious, marching up to the barrier with a look of childlike innocence, and at times with a smirk of sophistry, and, with luck, getting through with a *Rücksack* crammed with chocolate, tea and tobacco, all of which will bring a profit of several hundred per cent at the next village. Nominally these Swiss or Germans living on the German side of the border, but earning their daily wage in Switzerland, were until recently allowed to take out as much food as they needed for their own consumption; but when, better late than never, the Swiss *douaniers* realized that they must be spending more money on each day's victuals than on a year's clothes, the allowance was appreciably curtailed.

CYCLIST AND PEPPER

Among articles which have lately fetched the highest prices in Germany are pepper (said to be employed in the manufacture of lachrymatory shells) and saccharine. Both are commonly twisted up in little paper bags and thrown across the frontier to accomplices, though one enterprising cyclist, seeking profit on a higher scale, actually filled the frame of his machine with pepper. His ingenuity would have met with its reward but for an unlucky jar which released some of the pepper. This found its way, as ill-luck would have it, to the nostrils of a customs official, and the pepper, as well as the cyclist, remained in Switzerland. All manner of accomplices, including dogs, children, and seductive young women, who distract the attention of the sentries, are enlisted in this traffic, and it is said that at the village of St. Ludwig alone, where smuggling is very capably organized by the official German Censor, 40 families live by it.

Cotton and rubber are always welcome. A good deal of the rubber is shot out of catapults, and both the sender and the receiver have developed surprising skill after months of practice, darkness being apparently no obstacle. For the transit of cotton feminine subtlety is available. Hundreds of young women used, until their little fraud was detected, to earn high wages by merely passing the barrier, apparently without luggage of any sort; arrived at the appointed *cache* they would divest their more or less shapely limbs of voluminous cotton unclothing supplied by German agents on the Swiss side, taking in exchange such money as had been left for the purpose.

All manner of metals, particularly brass and copper, were at all times eagerly sought by the German military authorities, as not even the melting of all the finest church bells could keep pace with the demand. The Swiss newspapers have for months been full of advertisements for copper in small quantities; but, not satisfied with such sources of supply, the German agents engaged a willing band of thieves to go round more than one Swiss frontier town at night and wrench the brass plates from the front doors of doctors and other professional men. Even this little plan failed, for, like some others, the thieves never knew whether the master of the house came at midnight or at the cockcrowing, and one of them was caught red-handed.

"WINE FOR STOCKHOLM"

All this is smuggling on the petty scale, and, although the aggregate is no doubt serious, it may safely be said that a single smuggler *en gross* sheltering under an established reputation or taking advantage of peculiar "connections," is able to get more contraband into Germany on a single train than all these small fry can carry over in a year. Success does not necessarily cast any imputation on the *bonafides* of the S. S. S. The officials of that organization work early and late during the day, but unfortunately the Germans work all night as well and are thus able to hoodwink those in authority. As a case in point, considerable quantities of wine were recently got through Switzerland into Germany—apparently with the necessary export permits, since immense casks of wine do not lend themselves to surreptitious transit. It looked rather a puzzle, but the solution was very simple. A number of honest Swedish wine merchants, with excellent addresses at Stockholm, advertised in the Swiss newspapers for the wine, and for its export to another neutral country the Swiss authorities, with perfect propriety, issued the necessary licenses, and in due course were shown the receipts, all in order, from Stockholm. Yet the wine never went near Stockholm, and never crossed the sea at all, but was diverted, as soon as it was over the German frontier to addresses within the Fatherland.—*London Times.*

Burmese Black Varnish or Lacquer

BURMESE lacquer is similar to Chinese lacquer and is likewise used in a liquid state as a varnish for woodwork and for waterproofing paper and cloth. Mixed with pigments as a decorative paint, or with ashes or teak sawdust it is used as a putty basis on woodwork or basket ware preparatory to application of finishihg coats of the varnish. It is also used as a cement for glass mosaics in Buddhist temples. Figures are given showing the yield and value of "thitsi" (its native name) from different Forest Circles in Burma. Samples of three grades sent to the Imperial Institute for examination showed that the grading was dependent on moisture content only, the dried product being identical in each case After application the varnish becomes hard in three days at 30°-35° C. in an atmosphere saturated with moisture, but remains sticky for several days when exposed in dry air at the normal temperature. In submitting samples of thitsi for trial to varnish chemists, manufacturers, and firms specializing in lacquer ware, reports on the material were obtained from which the following may be summarized; "Thitsi" appears to be quite equal to Chinese lacquer, although slower drying. It shows advantages over Japanese lacquer, but owing to the conditions required for its hardening, it does not seem to find favor as a substitute for other materials drying more quickly at ordinary temperatures. In view, however, of its special resistance to chemical and physical influences and its great elasticity, it would appear desirable, according to one report, to ascertain if the disadvantages accruing from the special conditions required for hardening it could be overcome without much difficulty. There appears to be little prospect of thitsi being exported extensively for use in Europe, but there should be a large demand for articles lacquered with the material locally.—Note in the *Journal of the Society of Chemical Industry* on an article in *Bull. Imp. Inst.*

Fig. 2. Carvings on a large rock above the second pool of the waterfall at Reef Bay

Fig. 3. Petroglyphs on the lower part of the large rock at Reef Bay shown in Fig. 2

Archeological Notes on the Danish West Indies

The Petroglyphs of the Island of St. John and of Congo Cay

By Theodoor de Booy, of The Museum of the American Indian-Heye Foundation, New York City

THE writer of the following monograph was sent by the Museum of the American Indian-Heye Foundation, of New York City, to make an archeological survey of the Danish West Indies and more particularly of the principal islands, St. Thomas, St. John and St. Croix. His work consisted principally in the excavating of pre-Columbian village-sites but having heard of the existence of Indian rock-carvings (petroglyphs or pictographs) on the island of St. John, he considered it necessary, in order to make the archeological survey the more complete to investigate the site where these rock-carvings were found. The writer was later told of some other carvings on a large boulder on Congo Cay, a small island lying in the passage between St. Thomas and St. John, and after an examination of this site, considers it of sufficient interest to students of West Indian archeology to include a report of it in this present paper.

But little has been written on the petroglyphs found throughout the West Indies. The writer cannot accept the so-oft stated fact that the presence of carvings of this character indicates an ancient site of worship. He does not mean to imply that the carvings themselves are utterly meaningless, as no Indian would spend the time that it undoubtedly must have taken to chisel the carvings out of the hard surface of the boulders upon which they were engraved. He is of the opinion that the petroglyphs naturally had some meaning but considers it best to leave the solution of this problem until a systematic compilation has been made of all rock-carvings found in the Antilles. And after this thorough compilation has been made, it is still very doubtful if the problem can be solved.

An examination of the illustration, Fig. 1, will convince the reader of the reason for the name Reef Bay. This inlet is situated on the south coast of the island of St. John and is named Kip Bay on some old charts and Rif Bay on others: the more modern and the local appellation however seems to be Reef Bay.

In olden days, Reef Bay estate seems to have been of considerable importance as a sugar-factory but with the decline of the price of this commodity, the estate fell upon evil days, as did numerous other sugar-plantations on the island.

The writer is indebted to Mrs. L. Marsh, the present owner of the Reef Bay estate and to her son, Mr. E. Marsh, for permission to take photographs on the property and more especially to the latter for his kindness in acting as guide to the writer when he visited the estate.

Following the road between Lamesure, another bay upon the south coast of St. John, situated more easterly than Reef Bay, one sees the waterfalls under which the rock-carvings are found, from a considerable distance. The falls lie between the ridges of two hills, and in reality consist of two waterfalls, the upper one some sixty feet high and the lower one, under which the carvings are found, forty-five feet high. As the crow flies, the falls are not more than one and one-quarter miles from the sea.

In order to visit the site, one has to follow a dried-up watercourse and then cut one's way through a somewhat dense thicket. Before the hurricane of October 9th, 1916, there was a small footpath following this watercourse and the ascent to the falls was far easier than it is today. It is only a matter of time however, before this path will again be accessible.

The lower fall, forty-five feet high, does not have a considerable volume of waterfall in ordinary times. During heavy rains, the amount of water passing over

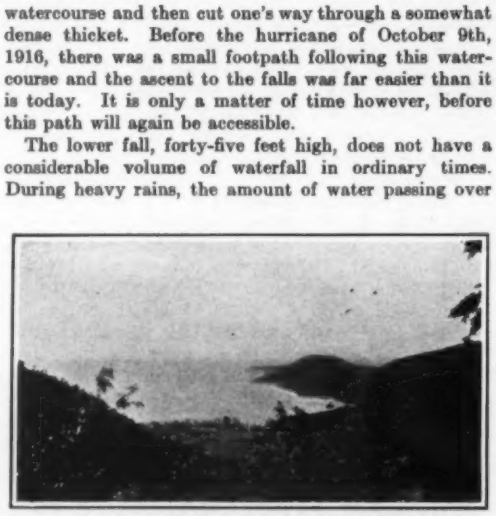


Fig. 1. Reef Bay, Island of St. John, Danish West Indies

the rocks must be quite large. It appears that in present times, even with the longest periods of drought, the falls seldom are devoid of water and it can therefore safely be said that in Indian days, when the island was heavier wooded than it is now, the falls were never dry.

The lower waterfall empties itself into a pool some five feet deep and about twelve feet in diameter. This pool empties its contents into a second pool about seven feet lower than the first. The second pool, in which the water is quite tranquil, is about 6½ feet deep, 14 feet wide and 9 feet broad and makes an excellent bathing-place. The water, filtered during its long passage through the hills, is excellently adapted for drinking purposes and the writer is of the opnion that the Indians inhabiting the south coast of St. John must have come here for their supply of drinking-water.

Fig. 4. Carvings on west side of pool at Reef Bay

It is on the rocks surrounding the lower pool that the petroglyphs are found, Fig. 2 shows the carvings on the upper part of the large rock above the second pool. Fig. 3 illustrates the carvings on the lower part of this same rock and also shows the undisturbed surface of the pool itself. Fig. 4 illustrates the carvings on the rocks on the western side of the pool.

There is nothing very remarkable about the carvings shown in Fig. 2. The figure shown on the extreme left of the photograph is 19 inches long and the largest circle of this figure is 10 inches in diameter. This carving probably represents a conventionalized human figure. The size of the other carvings shown in this picture can be computed from the dimensions given of the one, the left hand, figure. Yet another conventionalized human figure is shown about in the center of the photograph. Directly above this can be seen two human faces, represented by a circle, two pits for the eyes and a line for the mouth. The writer cannot solve the significance of the intricate figure situated between the two conventionalized human figures, nor can he determine the original significance of the carving on the extreme right hand side of the photograph.

The lower part of this same rock, shown in Fig. 3, possesses more carvings and unless the Indian workers made these inscriptions by standing in the pool of water, the writer thinks they must have been made by workers who were lying flat upon their stomachs while they manufactured the inscriptions. The presence of a somewhat crooked line of pits is remarkable, all the more so as this line is directly above the normal water line of the pool and parallels this waterline fairly exactly. On the extreme left of the photograph we find the usual simple human face, consisting of a circle, two pits and a line. Another similar carving is found a little to the right and somewhat higher. Directly under this second human face can be found a carving of the same class excepting that the eyes are shown somewhat more elaborately by pits surrounded by semi-circular lines. The large figure in the shape of a figure 8 cannot be explained by the writer. Under this figure, a little to the right, are two scroll-like carvings which more than likely represent conventionalized human eyes. Next to these, to the right, comes a conventionalized human figure, the large circle representing the face, with inner lines for eyes and mouth, and the four lines under the circle representing the arms and legs. Above this carving, a little to the right, is what probably was another conventionalized human figure of which the lines representing the right-hand arms and legs have been obliterated by the action of the weather upon the rocks. The figures on the extreme right of the photograph again

Fig. 6. Landing at Congo Cay, and rock carvings

Fig. 7. Enlarged photograph of carvings on Congo Cay

represent conventionalized eyes. In order to give the reader an idea of the size of these carvings, it may be well to state that the distance from the human face on the left-hand side of the photograph to the carving on the extreme right is 10 feet 4 inches. The distance from the top of the largest figure, the one which looks somewhat like a figure 8, to the waterline, is 2 feet 3 inches.

But three carvings are found upon the rocks on the western side of the pool under the second waterfall. The lower of these looks like a cross. The height of this figure is 1 foot 5 inches and width of the arm of the cross 11, inches. (Fig. 4). It cannot be urged that the Indians inhabiting St. John copied this cross from the Christian teachings of the discoverers of the New World as the carving probably existed many hundred years before the coming of the *conquistadores*. The writer imagines that this carving may have represented a conventionalized "Swastika" symbol, used to show the four cardinal compass points. The carving directly above the cross is quite intricate and allows for no explanation. Neither does the carving shown on the extreme left of the photograph have any significance in the eyes of the writer.

All carvings at Reef Bay were of about the same depth, *i.e.*, ¼ inch. There can be no doubt that a number of additional petroglyphs existed in pre-Columbian days upon the rocks surrounding the pools of the Reef Bay waterfalls the action of the weather upon the rocks however obliterated a number of the carvings and one can but faintly make a number of them out today.

A series of small cays and islets lies between the islands of St. Thomas and St. John. One of the larger of these is called Lovango Cay and directly north of this lies a rocky cay called Congo Cay. Due east of Congo Cay lies Caravel Rock, Fig. 5. Lovango Cay is owned in part by Mr. Andersen to whom the writer is indebted for his visit to Congo Cay which is rented for fishing purposes by Mr. Andersen. It was due to Mr. Andersen's courtesy that the writer was given the opportunity of seeing the rock carvings on Congo Cay.

There is but one landing place on Congo Cay. One has to approach the cay in a rowboat and wait for an opportunity to jump upon the rocky ledge shown in the photograph. As the seas generally run quite high in the passage between St. Thomas and St. John, this jump is a somewhat hazardous feat and a misstep might mean fatal accident.

Congo Cay consists of nothing more than a rocky ridge, resembling in shape somewhat the fin of a shark. Vegetation is practically non-existent and the only advantage possessed by the cay is that it seems to be the best fishing-ground for line-fishing in the waters surrounding St. Thomas and St. John. It may well be that the Indians frequented it for this reason. There is no place on the cay to allow for the hauling-up of the Indian canoes and such visitors as came to the cay therefor must have been brought there by other members of the tribe who afterwards had to return to take them off again.

The carvings on Congo Cay are found upon the rock at the extreme eastern part of the cay. This rock is shown in Figs. 6 and 7. It will be noted that the rock lies almost horisontal and that it faces Caravel Rock to the eastward. There is a large cavity in the center of this rock and it was suggested to the writer that this cavity was artificial and might have been used to store the blood of the victimes of the Carib sacrifices. In the first place, the writer cannot concede the point that Caribs inhabited the islands surrounding Congo Cay. In the second place, Congo Cay, bleak, barren, hard to land upon and with no place upon it to hold sacrificial ceremonies, would be too exposed to the neighboring islands, to allow one to suppose that a marauding tribe of piratical Caribs would have selected this spot for their cannibal feasts. Thirdly, the cavity in the rock was undoubtedly caused by the decomposition of the stone and there are several rocks on Congo Cay that have cavities of this order. It is true that the opening of the cavity is somewhat smaller than the area of the lower surface of the hole, but one can readily understand that the cavity would fill up with water whenever the seas broke over Congo Cay during stormy weather and that this water would attack the sides of the cavity and make it larger without necessarily enlarging the opening.

The carvings on the rock—which are the only carvings that can be found on Congo Cay—are singularly uninteresting. They are shown in more detail in Fig. 7. The figure in the upper left-hand side of the photograph represents a conventionalized human face. To the right of this figure can be seen an even cruder depiction of a human face, consisting simply of a circle, two pits and a line. A little to the right of this again can be seen three circles with pits in their centers. Judging from the arrangement of the circles, the two that are close together probably represent the eyes and the separate circle the mouth, so that the three circles together again represent a human face. In the center of the lower part of the photograph can be seen a circle which enclose two circles with the usual pits. The large, outside circle, has an appendage of four lines. The entire carving probably represents a conventionalised human figure. To the right of this can be seen two concentric circles with a pit in the middle. As in Reef Bay, it is likely that a far larger number of petroglyphs existed upon this rock in pre-Columbian days but that the action of wind and water has obliterated a number of them. The carvings were about ¼ inch deep. To give the reader an idea of the size of these carvings, it may be well to state that the size of the cavity shown in the photographs is: width 13 inches, depth 3½ inches, length 44 inches. From the figure in the extreme left of the photograph shown in Fig. 7 to the figure on the extreme right in the upper part of the photograph is 31½ inches. The rock itself is about 35 feet above seawater level.

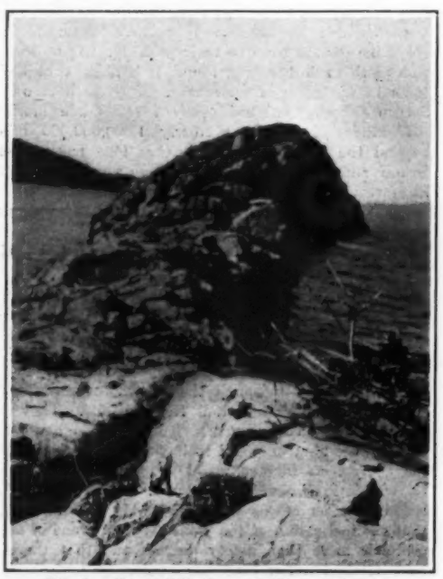


Fig. 5. Caraval Rock, a small cay between St. John and St. Thomas

The writer discovered some evidence upon Lovango Cay that this islet had been inhabited by the pre-Columbian inhabitants of this region and it may well be therefore that the members of this tribe came to Congo Cay to fish. What appears to be an artificial mortar-hole, about 5 inches in diameter and 4 inches deep, can be found in one of the rocks near the rock upon which the carvings are found. It is possible that this mortar hole was used by the Indians for pounding the salt used for the curing of the fish caught by them during their stay on the cay.

Black Photographic Images Produced by Kathode Ray

IT is well known that kathode rays can produce two entirely different effects when they fall on a photographic plate. For short exposures the part of the plate on which the rays fall is blackened: for lengthy exposures a kind of "solarization" (see T. Retschinsky, Jahrb. d. Radioakt. 13. p. 75, 1916), or photographic reversal, is obtained. The author considered that in obtaining photographic records of deflections of kathode rays (*i.e.*, parabolic paths on the plate) short exposures would result in sharper and blacker photographs. Experiments have been made to determine the best conditions for obtaining such clear photographs, with the following results: (1) There must be a direct connection between one of the two electrodes (deflecting the rays) and the case of the camera; (2) the pressure must be the lowest possible, not only in the camera but also in the discharge chamber itself; (3) a high discharge voltage is essential.—Note in *Science Abstracts* on a paper by M. WOLFKE in *Phys. Zeits.*

Arc Light Efficiency

RECENT improvements in searchlights have taken the form of various methods of cooling the electrode with a view to obtaining greater local concentration of the light, either by a spray of alcohol, or, as in the Sperry searchlight, by a blast of air. Another line of development being investigated in Germany has been the use of arcs under high atmospheric pressure. Lummer was reported to have obtained promising results shortly after the outbreak of war, and it was thought possible that a considerable improvement in the efficiency of arc lamps and projectors might be secured in this way. According to some experiments described in the *Elektrotechnische Zeitschrift*, this anticipation is not being realized. Pressures varying from a vacuum up to five atmospheres compression were utilized, both with inclined and vertical carbons. In the former case a marked gain in efficiency was secured, but the arc was found to become very unstable for pressures exceeding one atmosphere, says the *Electrician*. On the other hand, with vertical carbons more stable conditions are realized, but the gain in efficiency seems to be very moderate.—*The Engineer*.

Companions of the Sun—II*

Some of the More Intimate Features of the Solar System

By Albert D. Watson

Concluded from Scientific American Supplement, No. 2188, Page 368, December 8, 1917

Passing over the minor planets for the present, we have now to consider briefly those four colossal orbs whose paths are far beyond that of Mars. They differ from the smaller major planets, not only in size, but also in constitution. They are much lighter than the smaller planets in proportion to their volume, and are in a much less solid state. Their size has probably prevented rapid cooling. They have a total of 24 moons whereas the four smaller major planets have, in all, only three moons. These four colossal planets include vast areas within their orbits. Neptune, the outermost, being nearly twenty times as far as Mars from the sun. The comparative areas included in their orbits is therefore almost one to four hundred.

Jupiter is far the largest of the planets. (Diameter, 84,000 miles.) It is larger, indeed, than all the others combined. How appropirate that this mighty sphere should have such a name! But is it not strange that Venus, who looks so much brighter, was not in pre-statistical days called Jupiter? Probably Venus was named first because of her greater brilliancy, and in virtue of her conspicuous beauty, received the name of the charming goddess, after which the only name worthy of the great planet we are now considering was that of the father of the gods.

Jupiter resembles the sun and Saturn in the fact that he is not solid at his surface. His equatorial regions, like theirs, float somewhat freely over the deeper layers of his body. The surface at the equator completes an axial revolution in less time than is required by the polar regions to complete theirs. This may not mean that Jupiter and the sun are slackening their pace. It may be explained by centrifugal forces. Juptier's axis is perpendicular to his orbital plane, which is inclined to the ecliptic at an angle of only 1° 8″.

Seasons are absent from Jupiter's year, which is equal to about twelve of ours. He therefore passes eastward, as seen from earth, through about one zodiacal sign each year. The Jovian day is less than ten hours, or about twenty minutes less than the day of Saturn. Bodies weigh about two and a half times as much as on the earth and 20 per cent, more at the poles than at the equator. Jupiter and the poles of Saturn are the only places in the solar system, away from the sun itself, where bodies weigh heavier than on earth. There are 10,455 days in the Jovian year. A point at the earth's equator moves a little over 1,000 miles per hour, a similar point on Jupiter's equator moves about 26,000 miles per hour.

Jupiter has nine moons. The four largest were discovered by Galileo, being among the very first objects revealed by the aid of the telescope. The latest Jovian moon was discovered in 1914 by means of the photo-plate, the object being too distant and too small to be seen with the largest telescope. This latest discovered satellite moves in an orbit whose diameter is about 32,000,000 miles. Its motion is, like that of the satellites of Uranus and Neptune, apparently retrograde.

The succession of transits, occultations, eclipses, etc., of Jupiter's moons as seen from earth are among the most interesting phenomena an amateur can study and observe. The author of this paper remembers gratefully the excellent three-inch archromatic telescope through which he had a first glimpse of Jupiter and his four great moons, and has almost tender reminiscence of the little, old gentleman who so graciously afforded him that great pleasure.

Interesting as the Jovian lunar phenomena are, as seen from the earth, they would be much more so if they could be viewed from the planet itself. At present we may but sigh and piously express the hope that some day all that is indestructible in death's tremendous adventure may be clothed in a body so ethereal as to defy all those chemical and physical changes which set barriers here to our complete freedom. If such a faith be well founded, and some of us think it is, we shall then see the beauties of the worlds that are now only ideal, we shall perceive the subtle forces that dwell beyond the violet rays and hear the music of the ultratonal harmonies.

From the disparity between the predicted and the observed times of eclipses of Jupiter's moons, a time element was found to exist in relation to the movement of light from one part of the universe to another. Before that, light had been supposed to move to any distance instantaneously, as we have up to the present supposed gravitation to act. Even gravitation has recently been made the subject of question in relation to a time element.

Saturn. It is about 400,000,000 miles from the orbit of the earth to that of Jupiter. Another 400,000,000 miles brings us to the orbit of Saturn, the second largest of the planets, Jupiter is 1,300 times the volume of the earth. Saturn is 770 times the same volume. The body of Saturn (diameter, 73,000 miles) is not yet rigid and its axis is inclined to the plane of its orbit at an angle of 27°. The seasons are well marked in the Saturnian year, but each quarter lasts about seven terrestrial years. Bodies weigh more at the poles of Saturn and less at the equator than on our earth.

The most distinctive feature of this planet in his unique system of rings. These are in the plane of Saturn's moons, with the exception of the outermost moon which is apparently retrograde in motion. The rings consist of meteors. From the centre of the planet to the circumference of its outer ring there are, first,the 36,500 miles of the radius of Saturn. From the surface of the sphere to the inner margin of the inner rings is 9,000 miles. This, which is known as the crepe ring, is 12,500 miles in width and runs into the middle ring which is 17,000 miles wide. Outside the middle ring is a space of one thousand miles before the outer ring, 10,000 mile wide, is reached.

As Saturn's orbit is inclined to the ecliptic at an angle of 2° 30′ we should always see the Saturnian rings as a linear projection were it not for the inclination of his axis to the plane of his orbit. This leaning towards us of one or other of his poles shows us sometimes the north, at others the south, side of the rings and occasionally at the transition point, the linear configuration is seen. Only the most powerful telescopes will show the rings at all when they lie edgewise to the plane of our vision.

Saturn has ten moons, only one of which (Titan) is larger than ours. The first four, like our own and some of the moons of Jupiter, have been proven to turn always the same surface towards their primary. As no exception to this rule has been found, it is likely that it obtains in the cases of all moons. The ninth moon of Saturn (Phoebe) has technically a retrograde motion.

Uranus and *Neptune.* Nearly 1,000,000,000 miles beyond the path of Saturn is that lone track where Uranus runs his silent course and from which he beckons his farthest frontier signals to our unassisted vision. Thus between the orbits of Saturn and Uranus, the entire solar system as far out as Jupiter and his farthest moon might easily perform all their revolutions. The same may be said of the space between the orbits of Uranus and Neptune. These two planets might well be called the lonely worlds, since each of them is more than ten sun distances from any other planet.

Uranus appears as a faint green star and is 65 times as large as the earth. The spectroscope reveals a substance in the Uranian atmosphere not known to us on earth. Uranus has four moons and Neptune one. They are all smaller than our moon. These planets and their moons were long supposed to have a retrograde motion, *i.e.*, the planets were supposed to rotate and the moons to revolve in a direction contrary to that usually followed by other moons and planets. It is now thought that the inclination of the planets to the plane of their orbits is more than ninety degrees and that therefor their motions follow the general rule.

Technically speaking, the motions of these planets and moons are retrograde, but an interesting theory is gaining favor which claims that this was originally the direction in which all moons and planets revolved, and that the west-to-east movement was a later development. Ten pounds on earth would weigh nine on Uranus, and a few ounces less on Neptune.

Neptune. The story of how Adams and LeVerrier worked out the position of Neptune mathematically before the planet had as yet been seen, basing their calculations upon the reported deviations of Uranus from his predicted course, is well known as one of the most brilliant achievements in the history of science. In such subtle manner does the human mind come into a real harmony with that unseen Force that swings the balanced worlds. Such vivid and conspicuous results of our investigations of law would almost tempt one, with Pythagoras, to strain the ear and listen for "the music of the spheres." Like Uranus, Neptune has a far-reaching atmosphere.

The Minor Planets. Beyond the orbit of Mars, yet within that of Jupiter, lie several hundreds of bodies, all of them less than 500 miles in diameter, known as the minor planets. The theory has been advanced that these are the fragments of a shattered major planet that has been broken up and scattered in detail throughout this region. The irregular shapes and motions of many of these small bodies seem to support such a theory. The presence of such a planet was long suspected in this region, a fact which lends further support to such an idea.

Certain analogies as to the distances of the respective planets from the sun (Bode's Law) led a number of astronomers at the beginning of the nineteenth century to suspect the presence of an undiscovered planet between the Maritan and Jovian orbits. They instituted a methodical search, but an outsider, Piazzi of Palermo, was the first to discover a new planet. This was named named Ceres. Others were soon discovered and named after the classical godesses till such names were exhausted. Other names have since been used, but resort is now had to numbers, for over 800 of these minor planets have been discovered, catalogued, and marked on the "zodical way-bill." They vary in diameter from a few hindred yards to about 500 miles. Only one of them, Vesta, the third largest in size, can be seen by the unaided eye, and then only under the most favorable conditions. Its diameter is about 240 miles.

The orbits of the minor planets are inclined to the ecliptic variously up to 30°. They move in very eccentric orbits. Their combined volumes are not equal to more than one-fourth that of the earth, and it may be far less. Gravity on the surface of such small bodies is quite inconsiderable, and it is believed that a human arm might, even on the largest of them, cast a stone into space so forcibly that it would never return.

The most interesting of all these minor planets is Eros. It is the only one within the orbit of Mars. It approaches the earth more nearly than any other planet, major or minor. Its next nearest approach will be in 1938, when it will be within 13,500,000 miles. It rotates in five and a half hours. Its diameter is probably about twenty miles.

Comets and *Meteors.* Comets are aggregations of meteors, dust and vapor, and meteors are particles of disintegrated comets. Conets are the product of irregular or so-called accidental cosmic action. Meteors are cosmic debris resulting from attractions and repulsions that must be almost constantly active in one or other part of the heavens. The meteors are dead bodies left on the battlefields in the great war of the worlds.

The breaking up of Biela's comet in 1846 is a well-known incident in the history of the subject. The comet returned in two parts widely separated in 1852, and in 1872 as a meteoric shower which was unquestionably a part of the comet.

Comets and meteors are all probably of solar origin. This theory is strongly sustained by the fact that no element or substance foreign to our system has ever been found in any of these celestial adventurers. So far as has been ascertained, they all move in closed or eliptical courses. The solar system, therefore the earth's atmosphere, is moving constantly in one direction. If comets and meteors were not all of solar origin, they would assail the earth's atmosphere chiefly from that portion of the heavens which confronts it in its onward course. There would at least be a distinct preponderance of these bodies seen from that direction. But no such preponderance is found.

The distinctive features of comets are thus reduced to their peculiar phenomena, and their amazingly eccentric courses. The nucleus of a comet consists of an agglomeration of meteors, the coma, of dust and vapor: and the tail, which is acquired only when near the sun, is the product of radiant and electric energies (acting on microscopic particles)in excess of the force of gravity, thus giving a direction always from the sun. The tail appears only when the comet comes near enough to the sun to be subject to its radiant and electric forces, and disappears when it passes beyond those influences.

The periods of comets—the cometary year—varies from a few months in some cases to thousands of years in others. Their courses reach often far beyond the orbit of Neptune, but no one knows how far some of them go. The lustre of a comet is enhanced if its advent occurs during a maximum sunspot period, therefore, also, during a period of maximum auroal display. The

Journal of the Royal Astronomical Society of Canada.

latest appearance of Halley's comet occurred when there was little sunspot activity, and the appearance was disappointing to some. Perhaps it might have been more stupendous had the sun been more active at the time. It is probable that comets and meteors keep always the same face sunward.

Meteors are uncharted masses of adventitous matter floating in space around the sun. Coming within the earth's influence, they are drawn into its atmosphere, where the friction may melt them and turn them into vapor, or failing complete vaporisation on account of their size, they may fall to the greound or into the sea, but in a few cases they pass through a part of the earth's atmosphere and out again into space.

In the case of the meteors of February 9th, 1913, when several groups of large meteors passed over the western hemisphere and the mid-Atlantic ocean, it is not known certainly whether they reached the earth's surface and were lost in the sea, or passed out of the atmosphere and went on their way. The latter is perhaps the more probable theory. They were very large and were observed for some thousands of miles before they disappeared. Their height has been variously estimated at from 25 to 45 miles. They made a distinct sound which took some time to reach the ear because of their distance away. This sound was in most cases not heard till after the meteors that produced them were out of sight. The comparatively slow procedure of these objects across the sky was remarkable, and the whole picture so ably dealt with by Prof. Chant and others in the *Journal* of May-June, 1913, was one of the most startling and remarkable seen by the eyes of the present generation.

Many specimen meteorites are on exhibition at various centres. They are composed chiefly of stone and iron.

Sisal

THE price of this product is likely to rule high in the future, and the success of Germany in East Africa should stimulate exertions in our territories. It is said that no failure of a crop has ever been heard of on suitable land. Provided the soil is rich in lime and not swampy, poor and gravely lands are very suitable, and therefore estates which have been worn out by sugar and such other crops will give good yields. The reason of the advantage of poor soils is that the life of the plant is much longer, running to ten to fifteen years.

The *Queensland Agricultural Journal* advises that the plants to form a plantation should not be higher than 10 or 12 inches, or even less. Older plants take a much longer time to start growing. When planting, all dry leaves at the base of the young plant should be taken off as in the case of pineapples, and the main roots cut off and pared as closely to the trunk as possible. They must be planted perpendicularly, and only the lower portion of the trunk must be covered. The distance apart in the field is a question of soil. In rich soil the rows may be 10 feet apart, and the plants at intervals of 6 or 7 feet. In poor ground 8 feet by 6 feet is as close as the plants should be set. Roadways should be left at intervals of five chains.

Once a field is planted, it may be practically left to itself, as there is probably no crop, except the castor-oil plant, which requires less care to bring it to perfection than sisal. At the same time, a little care is needed at the outset until the plants are robust. No weeds should be allowed to grow, nor any to overtop the sisal plants, as they require all possible light, air, and sun. Tall weeds may be mown down.

In about twelve months suckers will begin to appear, and in 24 months these will be produced at the rate of 100 per plant. These must all be removed for two reasons. One is that they deprive the mother plant of the nutriment it requires to produce large leaves and plentiful flower. The other is that the suckers are valuable either for extending the area under sisal or for sale to intending planters. To plant up 100 acres 60,000 to 100,000 suckers are needed.

The life of the sisal plant is intimately connected with the production of the flower-stalk, technically called the "pole." The life of the agave (sisal plant) is a comparatively long one, but the long life may be materially shortened by injudicious management. The sign of the termination of its existence is the sending up of the pole. This happens when the plant arrives at the cutting stage and the leaves are left uncut. It may also be the result of over-cutting. Much judgment is required, therefore, to ensure that no pole shall appear for 10, 12, or 15 years. When the pole has appeared, it should be notched and bent over as soon as it appears, in order that all the leaves on the plant should be ripened before it dies. In this way the plant is kept available for yielding fiber a year later than it otherwise would be. Immature leaves should not be cut. As a general rule, the ripening leaves gradually fall from the erect to the horizontal position on the plant. Then are the leaves to be cut. It should not be lost sight of that when a mature plant sends up its pole all its suckers at once follow suit and send up slender poles. Hence suckers from a poled plant should never be used in forming a plantation, as it will probably not be six months before the pole appears.

According to conditions of climate, soil, and the kind of plant, the first leaves will mature in from three to four years. For harvesting the leaves, account must be taken of their length and state of ripeness. The length of the fiber is one important factor in its fitness for the market. The least length admissible is 2 feet 6 inches, and every additional length increases its value. It is not advisable, however, to cut leaves until they have attained a length of three feet. These leaves will average about three pounds in weight, but they frequently attain a weight in the Brisbane district of from five pounds to seven pounds. If left long after the leaf has reached the horizontal position—*i.e.* at right angles to the trunk—the leaf droops to the ground, acquires yellow spots, and, when machined, much of the fiber is broken off short at these spots, and is only salable as tow. The unripe leaves produce a brilliantly white fiber, but these, as stated, must not be cut. The number of ripe leaves per plant when from three to four years old will vary from ten to twenty, according to conditions of planting, rising in subsequent years to forty or fifty. This does not mean that forty or fifty leaves are at once cut from each plant, but it refers to the aggregate of the year's operations. The leaves are cut with a curved knife. Proper cutting consists in cutting the leaves as close as possible to the trunk. Loose cutting results in a considerable loss of the strongest part of the fiber. If three inches of each 40 leaves are left on the plant there is a loss of 10 feet on each plant, or 10,000 feet on an acre. This is a matter well worthy of attention by sisal planters. One man should cut and tie up an average of 1,200 leaves a day.

As to yield of fiber, on average poor soils, plants 7 feet by 8 feet (799 to the acre), 7 pounds of fiber per plant, or 5,630 pounds per acre, is obtainable; but it is well to reckon on only 15 cwt. or 1 ton of marketable fiber per acre. One ton of sisal fiber is worth, in England, from £55 to £60. Once the plants have arrived at the cutting stage, no other labor is required in the field except the cutters and carters.

Machining is performed as soon as possible after the leaves are cut, as, if two or three days elapse, the fiber will be spotted and consequently of reduced value. The fiber is extracted by various machines, cheap and expensive, but all work by means of drums and beaters, which, as the leaves are passed in, beat off in one action the whole of the fleshy part of the leaves, leaving the fiber, except for drying, practically ready for market. The cheapest machines cost about £40, and require a two-horse-power oil-engine. They are made by J. Wilson engineer, Elizabeth Street, Brisbane. Other machines are made in Manchester, costing before the war about £75 and upwards. The American automatic machines, in which the leaves are laid on a carrier side by side, and pass continuously into the machine, coming out as pure fiber as fast as the leaves can be fed, cost from £400 up to £1,000, and will clean from 70,000 to 150,000 leaves daily. These require from 20 to 45-horse-power engines. The capacity of the Wilson machine is about 160 pounds of fiber per day.

Finally, there is no particular time for harvesting sisal leaves. The work may go on all the year round. One thing should be attended to—when the plants have been cut once, a sucker should be allowed to grow up near the parent plant, so that when the latter dies the new plant will have arrived at the cutting stage, thus avoiding the replanting of the field.—*The Colonial Journal.*

Pruning Fruit Tree Roots

FORTUNATELY for fruit cultivators, the cutting of a root has a different effect on growth to the cutting of the top. Cut a root, and it generally breaks into a number of weaker and more fibrous roots. The large root does not only break into several smaller ones of the same character, but into numerous roots of a different sort. Forks and fangs, earth borers, and rock cleavers give place to masses of fibre that mount up and skim the surface filth, instead of penetrating into the grosser regions of stagnant water or infertile subsoil. If these favorable results do not follow the first cut of the knife, they are sure to follow in the end if the process is skilfully performed. But the great end must never be lost sight of. The roots are pruned less to produce their numbers, or shorten their length, than to modify their character; and, in short, change them from barren into fertile roots. When this is done the top will follow the lead of the roots as a matter of course.

A change of place is almost as important as a modification of character. Roots are very much more the creatures of circumstances than is generally supposed. If badly placed, they deteriorate; if well placed, they will improve. Depth of root is important for timber growing. Could the tap root of oaks go down as fast and far as the top goes up, we should doubtless have much finer and straighter timber than we have. As the tap roots get stocked—split or broken into fibres—the top becomes stunted and spreading, and takes to the bearing of acorns instead of timber-making. This stage would have been reached much sooner had the tap roots either been cut off or turned in a horizontal direction. This is exactly what the cultivator does with the roots of fruit trees. He turns them sideways and keeps them near to the surface, and the change of place checks sterility and establishes fertility.

Root medium and the character of the root run likewise exerts a powerful influence on growth. Certain soils, either from their mechanical state, chemical composition, or mineral constituents, favor sterility; others induce fertility. It is somewhat difficult to give specific instructions or definitions of what to avoid or choose. So much may be said; all cohesive, extra retentive, or over-rich soils are to be avoided for fruit-growing. Neither are those at the opposite extremes, such as sand gravel, or peat to be chosen. The soil above all others for fruit culture is a wholesome virgin loam from an old pasture or common, on which the herbage is short and close, and adhesive enough to hang together in spadefuls. Such soil, smelling almost as sweet, though, of course, different from new-made hay furnishes the finest medium or root-run for nearly all plants, and for the development of fertility in fruit trees.

It is not necessary that anything should be added to it, as overdoses of rich food may induce the balance of vital force into sterile ways. Sand or clay will not be needed if the loam is of the right sort. In such a medium the roots of the most approved stocks will branch and rebranch until the entire soil is a network of fibers, the top responding in sympathy and acting in concert therewith.

Now that it is the custom to graft or bud many of the most popular of our trees and shrubs, it is often found that the host does not contain sufficient vigor to absorb the robust strength thrown up in the sap of the rooting stock, consequently robbers appear in the form of suckers. They are frequently seen among roses, and when the leaves are on can be readily distinguished on most of the H. P.'s and Teas because they carry seven small leaves instead of five larger ones. They are often cut off just level with the ground, but this method only adds to the trouble for it is necessary that they are cut away at their base. In the case of fruit trees the plum is, perhaps the greatest culprit as suckers are often produced yards away from the trunk, and if they are topped in the manner already mentioned they will increase and become very detrimental to the fruitfulness of the tree.—*Garden.*

Catalytic Decomposition of Benzoyl Chloride

BENZOYL chloride when passed with a current of hydrogen over finely divided nickel at 270°-280° C. furnishes to the extent of about 50 per cent a mixture of benzene and toluene, and about 40 per cent of diphenyl. The mechanism of the formation of the latter is obscure, but it appears to be conditioned by the formation of nickel chloride on the surface of the catalyst, and is not suppressed even when an excess of hydrogen is employed. With copper as catalyst benzoyl chloride is decomposed up to about 40 per cent into benzoic anhydride, the remainder being unchanged. A similar conversion occurs at 420°-450° C. with the chlorides of barium and thorium, with simultaneous deposition of carbon on the catalyst, and formation of carbon monixide and hydrogen chloride. The manner of formation of the anhydride remains uncertain.—Note in *Journal of the Society of Chemical Industry* on a paper by A. MAILHE and F. DE GODON in *Bulletin Society of Chemists.*

Rainfall with Air Temperature Below the Freezing-point

THIRTY-SIX cases of this phenomenon have been picked out from the records of three observatories in Japan. In the large majority of cases air temperature lay between 0 and —2° C. There were three instances with temperature below—5° C. The cases occur mostly in the early morning or at night, rarely in the daytime. In general the phenomenon can be explained by assuming the existence of a temperature inversion, the temperature a little distance above the surface being above the freezing-point. On the other hand, the author has shown from thermodynamical considerations that when condensation takes place continuously in highly supersaturated ascending air both snow crystals and raindrops are formed even though the air temperature is many degrees below the freezingpoint and this may be the explanation of the phenomenon in some cases.—Note in *Science Abstracts* on an article by S. TAKAYAMA in *Monthly Weather Rev.*

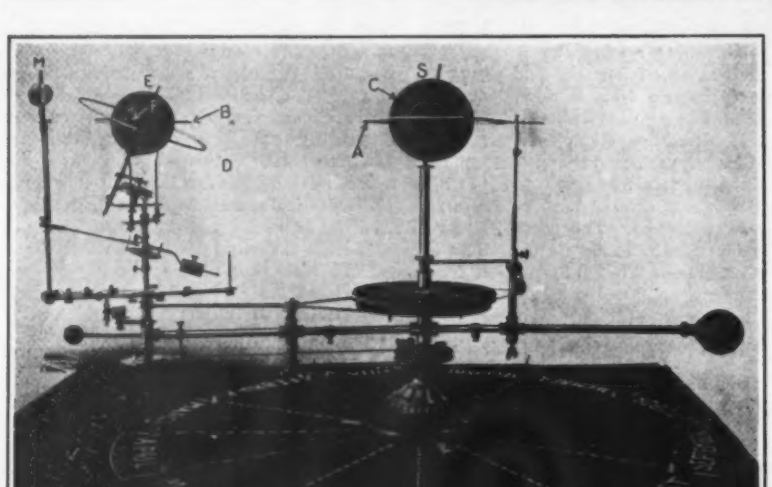


Fig. 1. Dr. Wilson's astronomical model

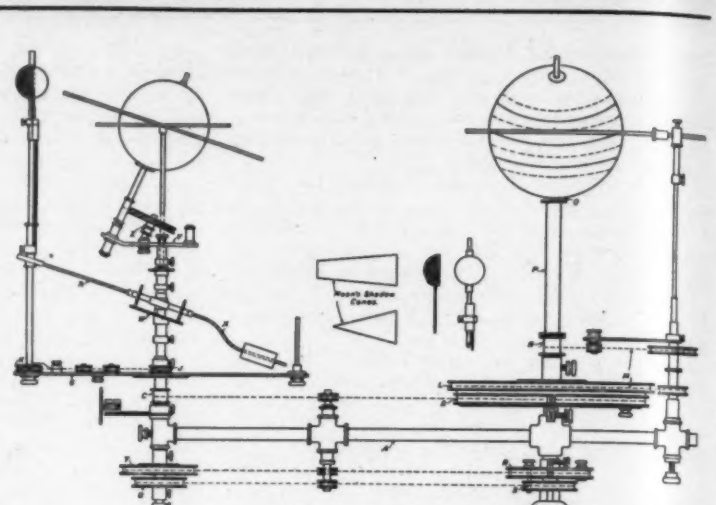


Fig. 8. General view of the astronomical model

How the Sun, Earth and Moon Move*

Illustrated by an Ingenious Mechanical Model

In the accompanying engravings we illustrate an astronomical model—or orrery or tellurion, as such devices are called—invented and made by Mr. W. Wilson, M.B., C.M., 43, Fellows-road, South Hampstead, N.W. 3. Dr. Wilson does not claim to be an astronomer. In actual fact he had an engineering training in his youth, but later turned to the study of medicine, so as to fit himself for medical missionary work. For thirty years he labored in this capacity in connection with the Chinese Inland Mission. While attempting to instruct the natives in elementary science he felt the want of a simple model wherewith he might demonstrate the relative movements of the sun, earth and moon. The model illustrated represents the culmination of his efforts to meet this want and it has already been exhibited and described before several of the learned societies. Before dealing with its construction it is very necessary that we should make a few remarks concerning the planetary system which it represents.

THE ECLIPTIC

The line joining the center of the sun to the center of the center of the earth in the course of a year sweeps out a plane which astronomers call the plane of the ecliptic. It is very important for reference purposes. In the model it is represented by the horizontal rings A and B, Fig. 1, surrounding the sun and earth, S, E, respectively.

THE SUN

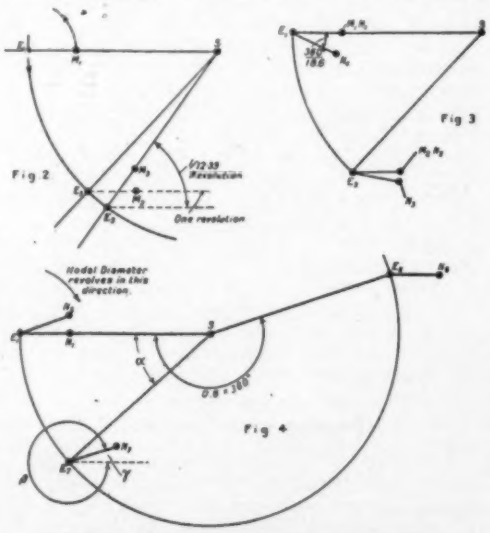
The axis of the sun is not normal to the plane of the ecliptic. As indicated in the model it is inclined to the normal at an angle of a little over seven degrees. The sun rotates about its inclined axis once in some twenty-five days nine hours. This has been discovered by noting the time taken for a sun spot, such as C in the model, to cross the disk and reappear again. The inclined path of such a sun spot demonstrates the inclination of the sun's axis. It may be taken as correct for our present purposes that the sun's axis is fixed in space.

THE EARTH

The axis of the earth makes an angle of about 23½ degrees, with the normal to the plane of the ecliptic. This is reproduced in the model. The earth makes one complete rotation round its own axis once in 23.934 mean solar hours, and performs its journey round the sun once in a year of 365.256 mean solar days. Its axis during its rotation round the sun remains constantly parallel with one fixed direction. Its orbit is not circular but elliptical, the major diameter of the ellipse being about 1½ per cent longer than the minor. This ellipticity is so small that it is suppressed in the model in favor of a strictly circular orbit. The sun is not situated exactly at the point of intersection of the major and minor axes of the elliptical orbit. If this orbit be regarded as a circle then it is a circle of 185,000,000 miles in diameter, and the sun is situated 1,500,000 miles out of its center. On the shortest day, in December, the earth is nearest the sun, the two bodies then being 91,000,000 miles apart. On the longest day in June, it is farthest away from the sun, the distance apart then being 94,000,000 miles. The variation of temperature from summer to winter is not caused by the variation in our distance from the sun, but by the constancy of direction of the earth's axis.

THE MOON

The orbit of the moon is inclined to the ecliptic at an angle of a little over five degrees. In the model, by reason of certain dimensions being necessarily out of their due proportion, this inclination has had to be considerably exaggerated, until it is nearly thirty degrees. The path of the moon M round the earth is indicated in the model by means of the ring D. The axis of the moon may, with sufficient accuracy, be said at all times to be normal to its orbit; that is to say, it lies at some five degrees to the normal to the ecliptic. In the model this is not reproduced, the moon's axis being made strictly normal to the ecliptic. The moon moves round the earth and simultaneously rotates on its own axis. As it always presents the same face to the earth it must rotate once on its own axis in exactly the same time as it takes to make one revolution round the earth. If the motion of the earth round the sun were stopped the moon would be observed to make 13.39 revolutions round the earth in a year. The cycle of phases through which the moon passes during the period between two successive "black nights" is called a lunation. There are 12.39 of these lunations each year. During a lunation the moon makes 1+1/12.39 revolutions round the earth. The excess of this figure over unity is required to compensate for the movement of the earth round the sun—see Fig. 2.



Diagrams illustrating principles of operation

THE MOON'S NODES

By reason of the inclination of its orbit the moon, during one half of its rotation round the earth, is moving above the plane of the ecliptic, and during the other half, below this plane. The two points in its orbit at which its center passes through the ecliptic are called its nodes. Since these two points lie in the plane of the ecliptic the line joining them, the nodal diameter, must always lie in the same plane. The nodal diameter in the model is the diameter common to the two rings B D. One of the nodes is visible in Fig. 1, being identifiable with the short horizontal member F on which the two rings are supported.

MOTION OF THE MOON'S NODES

In Fig. 3 let it be imagined that the moon M_1 is cutting the line S E_1 joining the earth and sun centers. Since this line is the generatrix of the ecliptic the moon is at the moment passing through the ecliptic, and is consequently at a node. The moon makes 13.39 revolutions round the earth each year, that is to say, it makes one revolution in 27 days 7 hours 43 minutes 11 seconds. After this interval let the position of the earth be that marked E_2. The moon, having made one complete revolution, should be at M_2— the line E_2 M_2 being parallel with the line E_1 M_1—and should be again passing through a node. This state of affairs would hold good if the moon revolved round the earth as center in a truly circular orbit at a uniform rate, if the plane of this orbit remained at a constant inclination to the ecliptic, and if any given diameter of the orbit remained constantly parallel with a given direction in space. In actual fact not one of these assumptions is true. The earth is not at the center of the moon's orbit; the orbit is elliptical and not circular; the speed of the moon is slower at one time and quicker at another; the inclination of the orbit to the ecliptic is subject to a slight variation, and, finally, the major—or any other—axis of the ellipse executes a slow rotary movement about the earth's center as a pivot, generating in the course of some years a complete cone.

Each of these departures from the simple conditions we have assumed has its effect upon the position at which the moon crosses the ecliptic for the second time after leaving the node N_1, Fig. 3. The net result of all the influences is that the node in question is not at N_2 but at N_3. In other words, the nodal diameter does not remain constantly parallel with the line E_1 N_1, but suffers a slow rotation round the earth's center. The moon cuts the ecliptic therefore at intervals which are slightly less than the time it occupies in making one complete revolution round the earth. It passes through the node N_3 27 days 5 hours 5 minutes 35 seconds after leaving the node N_1, or 2 hours 37 minutes 36 seconds before it has made a complete revolution. From these figures it can easily be calculated that, when the earth at the end of a year returns to the position E_1, the node is not at N_1 again, but a little way back at N_4, and that the angle N_1 E_1 N_4 is 360 degrees × 18.6. At the end of 18.6 years therefore the nodal diameter has made one complete revolution round the earth.

THE SAROS CYCLE

At the end of 18 years the nodal diameter has made 18/18.6 or 0.968 of a revolution, as shown at E_4N_4 in Fig. 4. At the end of 18.6 years it has made one complete revolution and is at E_5 N_5, this line being parallel with E_1 N_1, and the angle E_1 S E_5, being 0.6 of a revolution. It is quite clear that at some point of time between 18 years and 18.6 years the nodal diameter is coincident

From *The Engineer*.

with the line joining the earth and the sun, just as we supposed it to be at E_1 N_1 in Fig. 3. After $18+n/100$ years, let the earth be at E_7 and the nodal diameter at E_7 N_7. The angle α is clearly $n/100 \times 360$ degrees. The angle β is $(18 + n/100)$ /18.6 × 360 degrees, so that its supplement τ is $(0.6 - n/100)$ /18.6 × 360 degrees. Hence for α and τ to be equal we must have $n = 3$. From this we see that after 18.03 years—or 18 years 11 days—the nodal diameter again comes into coincidence with the line joining the earth and sun centers. This period of 18 years 11 days—or more exactly 6,585 days 8 hours—is known as the Saros cycle. It was discovered by the Chaldean astronomers, and is of great interest and importance in the study of eclipses. It is reproduced in the model with an error of less than a day, indicating an accuracy of one part in 6,585 or so.

ECLIPSES

The conditions which have to be fulfilled before a total eclipse of the sun can occur are, first, that one of the moon's nodes must be on the line joining the earth and sun centers, and, secondly, that the moon must simultaneously be passing through this node. If these conditions are missed by not more than 1⅓ days on either side a partial eclipse of the sun will occur. In Fig. 3 the coincidence of the moon M_1 with its node N_1 implies that a total solar eclipse is occurring at the moment imagined. Eighteen years and 11 days later the nodal diameter has made almost a complete revolution, and is in exact coincidence again with the line joining the earth and sun centers. Very curiously, the moon, during this period, takes exactly a whole number of lunations—223—so that it is passing through the node between the earth and the sun, and is therefore causing a second total solar eclipse. It is to be noted that half way through the Saros cycle, that is after 9 years 5½ days, the nodal diameter having made nearly *half* a revolution, is in exact coincidence with the line joining the earth and the sun centers, just as it is at the end of the Saros cycle. But the moon in 9.015 years does not make a whole number of lunations, and is therefore not in a position to cause a solar eclipse. But it has made a whole number of *half* lunations, and is therefore at this point of time being itself totally eclipsed. The importance of the Saros cycle lies in this, that at the conclusion of the period the eclipses of the sun and the moon repeat themselves in the same order and at the same intervals. Counting partial and total eclipses there are 29 eclipses of the moon and 41 of the sun during each Saros cycle.

THE MODEL

The general construction of the model will now readily be understood. A feature of it, distinguishing it from other orreries or telluria, lies in the fact that all the motions possessed by its parts are communicated to them not through gear wheels, but by means of pulleys and cords.

The mechanical principle upon which the various parts are driven is indicated in the sketch Fig. 5. In this let A be a bar pivoted at B so as to swing in a horizontal plane, and provided at each end with pulleys C D free to rotate relatively to the bar, and connected by an endless cord. If the pulley D is pinned to the bar, as at E, and the bar is rotated, the pulleys will not turn relatively to the bar. If the pin E is withdrawn and inserted at F, so as to fix the pulley D to some bracket or foundation, then, when the bar is rotated round B, the pulley C will rotate relatively to it. If the bar is rotated clockwise the wheel C will be rotated anti-clockwise, and *vice versâ*.

On the wheel C let another arm, G, Fig. 6, be fixed so as to rotate with it, and let the cord connecting the wheels C D be crossed. Let the fixed pivot B be extended upwards, and on it let us mount a model sun. On a spindle fixed to the other end of the bar A, so as to be coaxial with the pivot of the wheel C, let us mount a model earth. On a spindle fixed to the end H of the bar G let us mount a model moon. Then, on rotating the bar A anti-clockwise, the model earth will move round the model sun in a circular orbit, and simultaneously the model moon will move anti-clockwise round the model earth also in a circular orbit. The rotations of the sun and the earth upon their own axis have not yet been provided for, but the rotation of the moon on its own axis once during each revolution round the earth is secured simply by fixing it to the spindle at H, so that it cannot rotate thereon.

Let us now add two other wheels J K, Fig. 7, to the arrangement. The wheels are to be of equal diameter. The wheel J is to be fixed to the bar A and to be arranged coaxially with the wheel C. The wheel K is to be mounted on a sleeve free to rotate round the fixed spindle H of the moon. This sleeve is to be extended upwards to the moon, and there be provided with a hemispherical cap painted black and arranged to embrace one half of the moon's volume. The wheels J K are to be connected by an open cord. On rotating the bar A anti-clockwise, the bar G, as before, will also rotate anti-clockwise, but the wheel K, and with it the moon's cap, will rotate clockwise once each time the moon goes round the earth. In other words, the plane of the open mouth of the cap will always remain parallel with its first position. In the first position the cap is set to cover the half of the moon remote from the sun. Thereafter the relative movement of the moon and its cap results in the side of the moon remote from the sun always being shrouded. The moon being fixed on its fixed axis always presents the same face to the earth. At one time this face is fully visible. Half a revolution later the cap has hidden it from an observer on the earth.

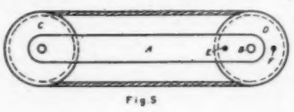


Fig. 5

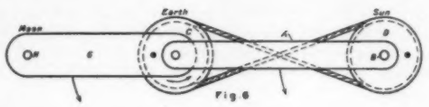


Fig. 6

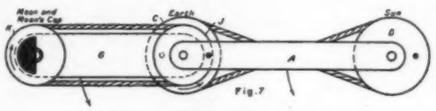


Fig. 7

Some details of the machine

In the general arrangement drawing of the model given in Fig. 8 we have lettered the two arms or bars A G, and the four wheels C D and J K to correspond with the diagram given in Fig. 7. Immediately above the fixed wheel D is a slightly larger fixed wheel L, which, by means of two endless cords M—or, an improved arrangement, as shown in Fig. 1, by means of one endless cord led over a set of tensioning pulleys—drives a pulley N fixed to a sleeve P. The sun's axis is fixed within this sleeve, and is bent at the top to the required inclination. The rotation of the sun on this inclined axis is produced by a short pin Q fixed to the top flange of the sleeve P, and engaging with an eccentrically situated hole in the bottom of the sun.

Two other wheels R S are fixed to the central post. The wheel R drives by an open cord the pulley T fixed to a sleeve, on which is mounted the bracket supporting the moon's orbital ring, and the ecliptic ring surrounding the earth—see Fig. 1, B D. If the wheels R and T were of exactly the same diameter the line joining the moon's nodes would remain constantly parallel with its first position, just as does the moon's cap. The wheel T is, however, made slightly smaller than the wheel R, so that the nodal diameter receives a small cumulative displacement in the plane of the ecliptic each time the earth goes round the sun. The sizes of the wheels R T are so chosen as to cause this displacement to reach one complete revolution in 18.6 years, as is required in connection with the cycle of Saros. The wheel S drives by open cord an equal sized wheel U fixed to a sleeve carrying a bracket V, which supports the inclined axis about which the earth rotates. As the bar A is rotated anti-clockwise round the central axis, the bracket V simultaneously is rotated clockwise round its pivot. In this way the axis of the earth is caused constantly to remain parallel with its first position, as is required to fulfil the condition that it should at all times point towards the Pole Star.

We have now only to explain how the moon is caused to rotate round the earth in an orbit inclined to the ecliptic, and how the earth is made to rotate round its own axis. The former effect is obtained by means of a cam plate W inclined to agree with the inclination of the moon's orbit, and fixed in position relatively to the nodal diameter. A weighted lever X, provided with two wheels which run on the plate W, is pivoted to a short sleeve sliding and turning freely on the tube carrying the bracket for the orbital and ecliptic rings. The end of this lever is forked to engage beneath a collar formed at the foot of a telescopic section of the hollow spindle, to which the moon's cap is fixed. The top end of the central solid spindle carrying the moon itself is flattened on one side to fit a corresponding hole in the moon's body. In this way the moon cap, rising and falling under the influence of the cam plate W, moves the moon up and down on the flattened portion of its spindle, but although the cap is slowly rotated simultaneously by the action of the pulley K, the moon constantly presents the same face to the earth because of the flat on its spindle.

The rotation of the earth on its inclined axis is effected in a very interesting manner. Radiating from the central standard are twelve arms of stout wire Y. The ends of these are bent upwards, and pass through a cloth on which the divisions of the year are painted—see Fig. 1. An endless cord is passed round these bent ends and is led up the central tube of the three concentric tubes carrying the pulleys U, T, C, Fig. 8. Emerging at the top of this tube it is passed round the pulley Z fixed beneath a larger pulley journalled on an inclined spindle which is fixed to the arm V. From the larger pulley a band drives on to a pulley formed on the earth's spindle. To demonstrate the model with the earth rotating, the endless cord is hitched to the bent end of one of the twelve wire arms. The rotation of the arm A, besides causing all the other movements, produces a pull on the cord which thus causes the earth to rotate. For many purposes it is unnecessary to demonstrate the rotation of the earth. When this is so the endless cord is simply unhitched from the arm Y to which it was attached. The rotation of the arm A then results in the cord slipping round over the bent-up ends of the twelve arms, the friction of which on the cord is not sufficient to overcome the friction of the earth's spindle and driving pulleys.

There are many interesting constructional features in the model. Among these we may mention the construction of the three concentric hollow spindles carrying the pulleys U, T, C, Fig. 8; the means adopted for adjusting the tension in the driving cords, and the splitting of the pulleys D and R, Fig. 8, so that their sizes may be delicately adjusted. The manner in which the whole model has been designed so as readily to be taken to pieces and packed away in a compact space is also interesting. As so much depends upon the absence of slip at all the driving bands, it may be remarked that the grooves of all the pulleys are lined with emery cloth.

The model is intended primarily for educational purposes. To this end the very estimable method has been adopted of demonstrating what actually does occur by showing what would occur if certain matters were otherwise than they are. Thus the moon can be caused to revolve in the plane of the ecliptic by throwing the lever X, Fig. 8, out of action. A total solar and a total lunar eclipse will then take place once a month. Again, by changing the bracket V the earth can be caused to revolve on a vertical axis. Thereby the variations of the year's seasons are clearly seen to be suppressed. Normally the wheel R is held stationary by means of a pin passing through it into the wheel S. By transferring this pin to a corresponding position in the wheels T U the moon's nodal diameter is caused to remain constantly parallel with itself instead of making one revolution in 18.6 years. In this way the Saros cycle is upset. Other hypothetical movements can also be arranged.

Appetite of the Mole

MOLES in captivity are notoriously difficult to manage. But Miss Frances Pitt has been remarkably successful in this undertaking, which she describes in the *Scottish Naturalist* for September. The extraordinary voracity of this animal is well known, but yet it is probably not generally realized that it will eat more than its own weight of earthworms in twenty-four hours. One of Miss Pitt's captives, weighing no more than 4 oz., ate during one month 7½ lb. of worms. Finding it difficult to maintain a supply for her captives, she experimented with raw beef, mutton, fowls' heads, and the livers of rabbits, with varying success. Cheese always seemed to be acceptable. Placed in glass boxes, she was able to watch them at nest building and excavating. When burrowing, the earth dug by the hands was thrown out by the hind feet, which were also used in cleaning the fur and the hands. But this paper, which has not yet reached its completion, is too full of interesting matter to be briefly summarized; it must be read at length by all who are engaged in the study of animal behavior.

Coal and Its Undiscovered Riches

FROM news coming through from Germany it appears that great attention is being paid there to plans for making the utmost economical use of coal. Much of the investigation work has been carried by the Kaiser Wilhelm Institut für Kohlenforschung. Among the discoveries announced is that by treating coal with liquid sulphurous acid at normal temperatures a viscous, golden mineral oil is obtained at the rate of about 5 kilos, to the metric ton. By treating naphthalene under pressure in the presence of aluminium chloride an excellent illuminating oil is obtained. Perhaps the most interesting experiments relate to the utilization of lignite. It is now being largely used as a fuel in the industrial establishments which have recently sprung up in the Central German lignite fields, especially in the neighborhood of Bitterfeld and Halle a/S, where the German air nitrate factories are situated. By a new process nearly twice the usual amount of ozokerite can be obtained from lignite, and the gas is being more extensively used for heating and smelting purposes.—*The Practical Engineer.*

Permanent Magnets*

The Effect of Chemical Composition, Shape, Dimensions, Heat, Treatment and Usage

By F. C. Kelley, Research Laboratory, General Electric Company

THE application of permanent magnets in the electrical industry is an important one, but the amount of work which has been given to this subject is comparatively small. The literature has been abstracted very well by Professor Silvanus P. Thompson in the Journal of the Institution of *Electrical Engineers*, Vol. 50, pp-80-142, and in the German by Dr. Ing. G. Eger, International Zeitschrift für Metalography. Messrs. C. F. Burgess and James Aston, of the University of Wisconsin, have done some very good work on this subject, which is reported in the *Metallurgical and Chemical Engineering Journal*, Vol. 8, pp-673-676, 1910.

The following is an outline of the literature on permanent magnets according to Professor S. P. Thompson:

1. Quality of Steel: Carbon steels; Alloy steels.
2. Shape and Dimensions: Short and long bars, curved shapes.
3. Heat Treatment: Normalizing, Quenching, Tempering.
4. Magnetizing: Methods; Appropriate intensity of field.
5. Maturing: By Ageing, by Mechanical Shock, by Reheating, by Partially Demagnetizing.
6. Conserving: Safeguards for Conservation.

CARBON STEELS

By means of the hysteresis loop we are able to determine the two most important facts that we ought to know about steel for permanent magnets namely, the remanent magnetism and coercive force; the height of the point where the curve cuts the vertical axis, and the breadth of the loop on either side of the zero point. The coercive force is the most important. The author quotes Prof. J. O. Arnold as authority for the statement, that though the magnetic permeability of a specimen is inversely protional to its carbon content, the amount of permanent magnetism retained is directly proportional to the carbon content. Arnold claims that the amount of hardenite, a sub-carbide of iron ($Fe_{24}C$), present determines the permanentness of a magnet. That is, the coercive force depends upon the carbon content, but not the remanence. He shows a curve by Dr. Carl Benedicks in which the coercive force is plotted against the carbon content. The coercive force increases between 0.5 per cent and 1 per cent and at 1.05 per cent carbon reaches a value of about $H_c = 50$.

ALLOY STEELS

Certain alloy steels containing other constituents beside carbon possess magnetic hardness and magnetic fixidity. Mushet's steel is an example of this class which remains hard when very hot; and when forged it is self-hardening without having to be quenched. This steel contains 7 to 12 per cent of tungsten, besides having 1½ to 2 per cent of carbon. Other metals, such as Mo, Cr, Mn and V, are used to give hardness to magnet steel. Manganese steel containing 12 per cent Mn and 1¼ per cent C is very hard, but curiously is almost non-magnetizable. Allevard steel is a very good magnetic steel and contains 5½ per cent of W and about 0.59 per cent C.

MICROSCOPIC EXAMINATION

Probably no advance in recent times has had an importance comparable with that connected with the application of the microscope to the study of metallic structures.

As the result of microscopic researches steels are known to contain certain structural constituents known as ferrite, cementite, pearlite, martensite, hardenite, austenite, etc., which can be recognised under the microscope. The amount of each one of these may be controlled by the temperature at which the steel is annealed, quenched or tempered. Then by this microscopic examination of different carbon and alloy steels, we have learned the effect which each temperature treatment has upon the structure of the steel under examination. The hard constituent called hardenite, which may be a solid solution of carbon in iron, or possibly a sub-carbide of iron is of the same percentage as pearlite, and is formed during any cooling that is so rapid that the particular pearlite structure has no time to form. This constituent appears to be the most important in magnets.

Diagrams of the equilibrium states of different carbon steels at temperatures varying from 500° to the melting point of pure iron have been made possible by the use of the microscope. From such diagrams it is possible to pick out the composition of the steel which is best suited for various uses.

Bar	Composition	B (Ret)	H_r
TABLE I			
WIC	(6 W+C)	13,450	30. as forged
156 E	8 Mo, 0.3 V, 0.6 C.	11,750	53.7 quenched
155 X	5 W, 0.5 C	11,700	59. quenched
136 M	5 Cr, 3 Mn, 4 Mo, 1 Si	11,350	55.8 as forged
160 P	4 W, 0.4 V	11,300	43.8 quenched
163 J	4 W, 0.4 V, 0.5 C	11,050	38.0 forged
155 P	1 Mn, 10 Mo, 0.5 C	10,750	58.4 quenched
155 K	10 Cr, 2 Si, 0.3 V, 0.6 C	10,700	32.9 as forged
163 P	4 W, 0.4 V, 0.6 C	10,650	35.5 as forged
150 C	2 Cr, 10 Mo, 0.5 C, 0.3 V	10,500	78. quenched
156 A	1 Mn, 2 Mo.	10,500	39.6 quenched
163 E	7 W, 0.3 V. 0.6 C	10,450	39.4 as forged
160 E	4 Mo. 0.6 V	10,400	35.0 quenched
160 C	10 Mo, 0.3 V, 0.4 C	10,350	59.8 quenched
155 Y	10 Ni, 5 W	10,300	35.2 quenched
136 V	10 Ni, 5 Mo.	10,150	36.7 as forged
141 F	10 Mo, 1.2 C	10,000	37.4 quenched
TABLE II			
150 C	2 Cr, 10 Mo, 0.3 V, 0.5 C	6,300	77.2 quenched
163 E	7 W, 0.3 V, 0.6 C	5,600	81.0 quenched
156 C	2 Mn, 5 Mo, 0.6 C	5,500	57.2 as forged
155 P	1 Mn, 10 Mo, 0.5 C	5,400	57.5 quenched
136 M	5 Cr, 3 Mn, 4 Mo, 1 Si	5,300	64.7 as forged
155 X	5 W, 0.5 C	5,200	52.5 quenched
133 K	6 Cr, 0.84 Si	5,200	52.3 quenched
150 D	2 Cr, 16 W, 5 Mo, 0.3 V, 0.5 C	5,000	63.5 quenched
163 H	10 Mo, 1 V, 0.4 C	5,000	53.5 quenched
156 E	8 Mo, 0.3 V, 0.6 C	5,000	52.2 quenched

TABLE III

Charge No.	Sclerescope Number	Brinell Number	B	Br	Hc	Br/Hc
1	73.5	594	16700	11415	44.66	256.0
2	63.0	534	14330	9040	52.40	172.5
3	70.0	548	15500	10285	50.00	205.7

Analysis, C, 0.50%; Si, 0.51%; Mn, 0.79%; Cr, 0.73%.

EFFECT OF SHAPE AND DIMENSIONS UPON MAGNETIC PROPERTIES

The shape and dimensions of a magnet have a great effect upon its retentivity, due to the fact that the poles of every magnet exercise a self-demagnetizing influence on the body of the magnet. The self-demagnetizing coefficient in the case of cylindrical barmagnets depends on the ratio of the length to the diameter, and this ratio has a great effect upon the qualities of the magnet. The shorter the bar, the nearer together are its poles, and the greater the demagnetizing action.

The demagnetizing effect in case of slit rings has been shown by H. Lehmann and H. DuBois to be nearly proportional to width of the slit, or gap in the magnetic circuit. It would be exactly proportional if there were no magnetic leakage, and if the gap itself were small compared with the radius of the ring. If the ring is provided with large pole pieces and the gap is narrow, the demagnetizing coefficient may be greatly reduced. Professor Thomas Gray found that the amount of remanent magnetism increased regularly with the dimension-ratio, that is, the ratio of the length to the diameter of the bars. Mme. Curie has also found this to be the case.

A laminated magnet has been found to be no more powerful than a solid magnet of equal weight and length.

HEAT TREATMENT OF MAGNETIC MATERIAL

In the heat treatment of magnetic alloys it has been discovered that when any specimen has cooled down through the recalescence stage it is capable of being magnetized. Since the coercive force of magnets depend upon the way they are hardened, it is essential for magnets which are to have the greatest coercive force that they be quenched at a temperature above that at which they recalesce, and quenched quickly. This has been shown by Mme. Curie, who magnetized an annealed bar and tested it. Then it was heated just below the point of reclaescence, quenched in water, magnetized and tested. Next it was heated above the point of recalescence, quenched in water, magnetized and tested. The magnet improved each time it was tested, but the improvement was greatest in the latter case.

Magnetic material which has had previous working should be annealed slowly and then quenched just a little above the point of recalescence. Mme. Curie tried experiments on the effect of quenching carbon steels of 0.06–1.20 per cent C and found that 770° C. was the best temperature for quenching. If quenched at 975° C. the remanence and coercive force both fell in value. She also found that the best magnet material, after hardening, if it be reheated to 905°, degenerated. By quenching first a little above and then a little below the point of recalescence, and going through this cycle several times, she found that the material could be improved and that the material which had become poor by over-heating could be repaired.

Barus and Strouhal tried some experiments on the effect of annealing on the magnetic qualities of permanent magnet steel, and found that annealing at a temperature which gave a blue tint produced the best results. They also found that for short bars a glass hard state, produced by heating to a bright red, and quenching in cold water, gave the best results.

Mme Curie has investigated also the effect of heat treatment on the alloy steels. Her two best carbon steels containing 0.84 and 1.2 per cent C are as good as can be found for any carbon steel, giving a permanence of 670 and 645, and a coercive force of 58 and 53 respectively. They were made in the form of rings. She found that Allevard steel (5.5 per cent W and 0.59 per cent C) not quenched, gave a remanence of 900 and coercive force of 26, but when quenched at 770° C. it gave a remanence of 850, and a coercive force of 26. Another tungsten steel ring (2.7 per cent W and 0.76 C) gave a remanence of 800, and 69 as the coercive force. A bar of the same material 20 diameters long gave 500 and 68 as corresponding values. Styrian steel containing 7.7 per cent W and 1.96 per cent C quenched at 800° C. gave corresponding values 370 and 85. This is considered a very good steel for short magnets. She also obtained very good magnet steels with the respective compositions 3½ and 4 per cent Mo. 1.25 and 1.72 per cent C. The statement is made that the tungsten steels which have proved best for magnets fall in two groups; (1) Those containing 5 to 7 or 8 per cent W with about 0.5 per cent C, and (2) Those containing 2½ to 3½ per cent W with 1 per cent C.

*From the *General Electric Review*.

Professor W. Brown examined chromium steels containing from 0.75 to 9.5 per cent of chromium. They have high coercive forces; but there seems to be little advantage in adding more than 2½ or 3 per cent Cr.

Campbell and Pierce have both shown that cast iron would make good magnets. Campbell, by quenching at 1,000°, found values of remanence from 200 to 229, and coercive forces from 48.9 to 52.8.

METHODS OF MAGNETIZING

The method of magnetizing bar magnets is to put them inside a long magnetising coil about twice as long as themselves. Short bar magnets may be put between the poles of an electromagnet, as may horse-shoe magnets. The field to which they are subjected should not be less than H = 250. Little depends upon the duration of the operation. There is a slight advantage in repeating the magnetization a few times by turning on and off the current. A slight advantage is gained by mechanical agitation while magnetizing and by not turning off the current too suddenly.

AGEING

Permanent magnets age with time, or lose part of their magnetism. Professor Thompson says that the most harmful thing that can happen to a permenent magnet is to slam on the keeper. Causes for the decay of magnetism of magnets are mechanical shock, changes of temperature, contact with magnets or iron, and exposure to demagnetizing forces. The lapse of time also apparently effects a deterioration. But in all magnets there seems to be a limit to this decay. The magnetism of a newly made magnet seems to be made up of two parts, a removable or sub-permanent magnetism, which slowly decays, and a really permanent part. Mechanical shocks and change of temperature help to get rid of the removable part. The time taken to get down to constancy varies with the quality of the steel and the dimensions ratio.

METHODS OF MATURING

Permanent magnets are matured by repeated gentle heating and cooling, protracted gentle heating, repeated subjection to mechanical shock, and partial demagnetization.

Barns and Strouhal found that by heating a glass-hard magnet in steam for 60 hours, then remagnetizing, and steaming again, its remanence was reduced to a constant value. After this treatment it was dropped from a height of 1.5 to 0.5 meter on a wooden block and it did not change over 0.54 per cent.

Mme. Curie found that heating magnets in steam caused a reduction of both coercive force and remanence, and that reheating to 200° C. was disastrous, for about 50 per cent of the original total magnetism was lost.

W. Brown found that glass-hard magnets resist shocks much better than others, and that those of higher dimension ratio were superior to those of a lower ratio. He also found that by prolonged reheating at 60° a constant state was reached with a reduction of from 1 to 3 per cent in best steels.

Mme. Curie found that an Allevard bar was rendere constant by shocks after it had been reduced 6 per cent, while carbon steel 0.5 per cent had to be reduced 40 per cent before it was constant.

Klemencic investigated the influence of allowing time to elapse between hardening and magnetizing. He found that the regular fall in their strengths was practically independent of the time when they were magnetized, and depended only on the time that had elapsed since they were hardened. This proves that there is sort of a self-annealing going on in the newly hardened steel, and that the molecular settling down of the material is scarcely influenced by the process of magnetizing. This settling down is hastened by boiling at 100°.

Krüse found that materials having the greatest coercive force had the least percentage loss from shock. He also found that drawing a magnet over the face of an iron plate had a reduction effect of 20 per cent.

SAFEGUARDS OF CONSERVATION

It is essential if a magnet is to retain its magnetism, that the keeper is not slammed on. A magnet should not be drawn over the surfaces of iron or steel and should not be subjected to the demagnetizing influence of other magnets. Care should be taken that a magnet is not subjected to constantly changing temperatures.

SUMMARY OF LITERATURE ACCORDING TO PROFESSOR THOMPSON

These results may be summed up as follows: To produce permanent magnets which are both constant and powerful, a tungsten steel should be used, having from 5 to 8 per cent of tungsten and from 0.4 to 6 per cent carbon. Chromium up to 2 or 2.5 per cent may be present, but the presence of manganese, titanium, copper, sulphur, and phosphorus should be avoided. For bar magnets the dimension ratio should be as large as possible. For horse-shoe magnets the gap between the poles should be short as possible, and the polar areas as large as possible.

The forging of magnet material should be done with as little working of the material as possible, and with as low a temperature as possible. After forging it should be normalized by raising to 900° C. lowered to 750° for a time, and then cooled off. To harden the magnets, they should be heated to 950° C. for 5 minutes only, then lowered to 700°, and quenched in brine or oil at 20° C. Some tungsten steels are better if quenched between 770 and 850° C.

There is no advantage in tempering tungsten steel. Magnets of carbon steel of 20 diameters may be tempered to a straw tint, and those of 40 diameters to a blue tint. Any letting down below a straw tint impairs their power to resist decay and usage.

Magnets should be matured by boiling or steaming for 10-12 hours or by heating them to 60° C. for 20 or more hours. There is some advantage in letting them cool several times during the process.

The magnet should be magnetized by an electromagnet, or, if a bar magnet, by a magnetizing coil, using the highest degree of magnetization possible. There is some advantage in reversing the magnetism a few times, but in the final magnetization the current should be turned off slowly to zero. There is an advantage in giving them a slight mechanical shock, Some magnets which are to have extreme constancy are subjected to demagnetizing forces.

WORK OF BURGESS AND ASHTON

METHOD OF TESTING

C. F. Burgess and James Ashton in their article published in Metallurgical and Chemical Engineering, Vol. 8, p-673-676, 1910, describe their method of testing as follows: They used an Easterline permeameter for their work. The bar was inserted in the permeameter, the magnetizing force H was raised to the maximum 200, and the density B (max.) was recorded. H was decreased to zero, and the retentivity B (Ret.) noted. Next the coercive force H_c necessary to reduce the retentivity to zero was determined. Similar readings were taken for the reverse magnetizing forces, and the average of these positive and negative readings B (max.), B (Ret.) and H_c for each bar was recorded for comparison.

HEAT TREATMENT

All of their samples were heated in a $BaCl_2$ bath to 1,000° C. and quenched. The authors recognize that 1,000°C. might not have been the best temperature at which to quench, but on account of the impossibility of obtaining the critical points for so many samples in the time allowed they quenched all at 1,000° C.

METHODS OF MATURING

Samples which showed a great retentivity and a coercive force of 30 were tested for stability. The bar was subjected to a maximum magnetizing force of $H_c = 100$ and the retentivity noted when the magnetizing force was reduced to zero. The bar was then, rapped, jarred or boiled. When boiled, the sample was enclosed in an iron pipe to shield it from magnetic fields, and the boiling was kept up for three hours. The authors claim but one vigorous rapping is necessary. The samples were tested as forged, and after quenching.

ALLOY STEELS TESTED

Chromium up to 16.65 per cent did not give high coercive forces, and these samples of high per cent Cr were no better than those of low per cent Cr. This agrees with the findings of Prof. Brown previously recorded. The best alloys had a Cr content of 5 or 6 per cent, plus 0.75—1 per cent Si or 0.3 per cent to 0.5 per cent of carbon. Cr in pure iron does not make a good magnet material. Vanadium increased the hardness.

Manganese with pure iron does not make a good magnetic material, because the retentivity is too low.

Molybdenum alloys with vanadium added showed no such hardness as in the case of Cr. Only one alloy showed up well in the forged condition, 8 Mo. 0.3 V, 0.6 C. It had a retentivity of 9,200 and a coercive force of 39.

In the binary alloys of Ni-Fe, an increase of Ni causes a decrease of retentivity and increase of coercive force. An alloy of 26 per cent Ni-Fe is non-magnetic. Alloys of higher per cent Ni are magnetic. Vanadium increased the magnetic hardness. Ni alloys are not regarded as a good magnetic material.

Binary alloys of W-Fe are not good for permanent magnets. The addition of vanadium may be beneficial, and the addition of carbon certainly is. The author's mention that all of the satisfactory alloys of this series except one contain carbon.

SUMMARY

In summarizing, the authors say that Cr, Mn, Mo, and W are important additions in the manufacture of steels for permanent magnets, but that the presence of a third element is necessary. While carbon is beneficial, highly satisfactory results are to be obtained with Si and vanadium, especially vanadium.

The following tables represent the best alloys obtained for permanent magnets. The first table represents results obtained before rapping or ageing; the second after rapping.

Some very good results were given in Professor Thompson's article on Remy steel, but I have not been able to find the composition of it.

WORK OF J. A. MATHEWS

Mr. J. A. Mathews of the Halcomb Steel Company presented a paper at the annual meeting (1914) of the American Society for Testing Materials, which brings out some very interesting points. The paper appears in the Proceedings of the American Society for Testing Materials Vol. 15, 1914, pp-50-66.

NEW FACTOR TO JUDGE MAGNETIC QUALITY

He devotes one section of his paper to the definition of the different magnetic units, and proposed a new unit to reprsent the factor Br/H_c which he uses to judge the magnetic quality of steels. He goes on to state that the coercive force alone is not a sufficient measure of permanence and that just as we use μ to denote permeability, in other words, the average number of lines of induced magnetism for each unit of magnetizing, H, so the factor Br/H_c indicates the average number of lines of residual induction removed by one demagnetizing unit of coercise H. The smaller the numerical value of this quotient, the greater the absolute permanence of the residual magnetism. The ratio of Br/H_c becomes almost constant above H = 200 and therefore permits of comparing tests made at different values of H. The instrument used for testing was the Esterline permeameter.

INFLUENCE OF CARBON UPON MAGNETIC AND PHYSICAL HARDNESS

In trying to establish a relationship between physical and magnetic hardness, it was discovered that for some heat treatments of an ascending carbon series when Hc was plotted against the Brinell number a straight line relationship was found showing the influence of carbon on both properties. In other conditions of heat treatment no semblance of a curve could be plotted.

EFFECT OF SIZE UPON MAGNETIC PROPERTIES

The work which was done to prove the effect of size upon magnetic properties is very interesting. Two different heat treatments were given steel of the following composition: C, 0.65 per cent; W, 5.22 per cent; Mn, 0.33 per cent. The material for these experiments was rolled down from the same ingot, the diameter of the magnets was varied, and the length was kept in the same proportion to the diameter. By quenching in cold water from 900° C .(1,650° C) the induction B, and residual induction Br, increased as the size decreased while Br/H_c showed the largest section to be most permanent. This is contrary to the experience in making horseshoe magnets, but it must be recalled that ordinarily for any given purpose, only the cross-section in them is changed, while the length and air-gap remain constant. Hence the rule applying to bar magnets applies to some extent to them, and as the ratio of section to length increases, the demagnetizing effect of poles increases, and a weaker finished magnet results from the use of large sections.

EFFECT OF QUENCHING UPON MAGNETS OF DIFFERENT SIZES

By quenching in lard oil from 875° C. (1,600° F) the opposite result was found, namely, the smallest section gave the best test, and in only the very smallest bars was the rate of quenching in oil fast enough to develop high permanence. These differences are explained by reactions in quenching.

These results may be contrasted with experiments of another steel of the following composition. C, 0.61 per cent; Si, 0.54 per cent; Mn, 0.82 per cent; Cr, 0.80 per cent. In these experiments the large samples, when quenched both in water and in oil, showed the best test for permanence. Judging either by the coercive force, H_c, or by Br/H_c, the larger section is best for permanence.

FACTS CONTRARY TO THE GENERAL IDEA ABOUT MAGNETS

The general idea about permanent magnet material is that the harder it can be made the greater its perma-

nence. Comparative testes on materials quenched in water or brine would be expected to show that the harder the piece, the less permeable, the lower its residual induction, and the higher its coercive force, but it is only true with certain steels under restricted conditions.

It is well known that the hardening capacity of steel decreases as its mass increases, yet it has been pointed out previously that the larger mass, and hence the softer piece, is magnetically most permanent.

It is well known, too, that the rate of cooling in oil is slower than water, and does not give as great hardness. Yet previously referred to experiments on steel, which was quenched both in water and in oil, show the relatively soft oil-hardened pieces when compared with the water-hardened pieces of the same size to have lower induction, lower residual and higher coercive force than the much harder water-quenched pieces, and the factor Br/H_c shows superior permanence of the oil quenched steel very clearly.

HARDENING OF MAGNET STEEL IN OIL AND WATER

Experiments on the hardening of magnet steel in oil and water (cold and boiling) are very interesting.

The results are given in Table III on page 382.

TREATMENT

1. Average quenching temperature of six bars, 815° C (1.500° F) in cold water.

2. Average quenching temperature of six bars, 843° C. (1,550° F) in oil.

3. Average quenching temperature of two bars, 843° C. (1,550° F) in boiling water.

The above results were verified in three separate series of tests on variable carbon ingots of the same type of steel, whose analysis is given above.

In the above table it will be noticed that No. 3 in all its properties lies between Nos. 1 and 2. This is not a peculiarity of this particular type of steel. It seems to be generally true of the great class of structural alloy steels, such as are covered in automobile-steel specifications. It holds good for chrome-nickel 3.5 per cent of Ni, and nickel-vanadium steels of various carbon contact. It does not hold good for two types of steel most used for permanent magnets, namely, common open-hearth magnet, of the type represented by C, 0.60 per cent; Mn, 0.75 per cent; 1.00 per cent; and high grade tungsten magnet steel of the type, C. 0.60 per cent and W, 5.00 per cent.

EFFECTS OF DRAWING THE TEMPER UPON MAGNETIC AND PHYSICAL PROPERTIES

Drawing temper of steel has a very marked effect on the magnetic properties. Hardness may be relieved by drawing the temper, but this gives results directly contrary to those due to retarded quenching rates. That is, the maximum induction and residual magnetism are increased, and the coercive force lowered. This is true whether the steel owes its original hardness to oil or water hardening, and it is also true that the effect of tempering is more marked on oil-hardened than on water-hardened pieces. That is, the augmented permanence in these alloy steels, due to oil hardening, is unstable, and this fact limits the possible commercial application of oil-hardening of magnets in manufacture.

Boiling in water has only a slight effect upon the magnetic tests, while drawing the temper at 205° C. (400° F), seriously impairs the magnetic permanence. This is true of both the structural alloys and the commerical magnet alloys. At a drawing temperature of 3/5° C. (600° F) the difference between oil and water tempering is wholly wiped out, and nearly identical tests result. Experiments on drawing to 315° C. softened the oil-hardened pieces physically to a less degree than the water-hardened piece. On the contrary, the greatest magnetic changes are in oil-hardened steels.

While drawing to 315° C. lowered the Brinell hardness 101 points in the water-hardened pieces, it lowered the oil-hardened pieces but 36 points; on the other hand, the change in B, Br and Hc is much greater in oil-hardened bars than in water-hardened ones, yet the total change brought both physical and magnetic properties approximately to a level, and wiped out the marked differences in the original properties due to oil and water-hardening.

SUMMARY

Mr. Mathews has shown results which seem to be out of the ordinary in that they are many times just the opposite of what one would expect. The fact that at present we are not able to explain these results shows the need of further investigation in this field. There is need of more information in order that we may have a better conception of the relationship between physical properties and magnetic properties, and that we may discover the laws govering these properties.

An extended bibliography of this subject, is given by Prof. Silvanus P. Thompson, in his paper referred to at the beginning of this article.

Fires in Coal Storage Piles

EVIDENCE accumulates that large quantities of coal placed in storage by railroad companies are being lost by fire. These losses apply to storage out of doors, in large piles, in open places, and, contrary to scareheads in the newspapers, it is not all the "work of Germans," either. It is well enough known that spontaneous combustion is the cause in most cases. In some instances it is clear that the source of the fire lay in conditions that were inexcusably bad, ordinary precautions, such as have been currently discussed and agitated among fuel department officials, not having been observed.

In the suburbs of a single large city (Chicago), immense quantities of locomotive fuel in storage, at more than five places widely separated, have taken fire. At one of these points the heap was more than thirty feet high and, to make conditions worse, it was accumulated by lifting the unloading track on the dumped coal and shifting it over as the cars were dumped at the edge of the bank. The coal was thus consolidated or compacted, cutting off ventilation and contribution to generation of heat.

It is a fact, nevertheless, that it is difficult to pile coal in large masses and surely prevent spontaneous combustion. An official who has had charge of storing large quantities of fuel this year, and who took precaution to observe rules that are commonly laid down for open storage of coal, informs us that he also has had much trouble from fire. In all cases the height of the piles was limited to fifteen feet, but it was found that, even then, the piles took fire wherever there was a considerable quantity of fine coal distributed through the mass. In order to have the piles safe against fire there must be ventilation throughout the mass, particularly at the bottom. It is also found that weather conditions have a good deal to do with the origin of these fires, and trouble is to be looked for after periods of heavy rains.

Unloading of coal into loose piles, with locomotive cranes and clam-shells, ditching machines and other equipment, is deemed safer practice than that of dumping it from tracks bearing directly upon the coal, as the compressive effect from superimposed loads exerts the same effect on coal in the bottom of the pile as does pressure from excessive height of pile. On some roads, however, there has been a shortage of equipment for handling coal onto the storage piles, and laborers for unloading were not to be had, at any price. Therefore, every machine in the form of locomotive cranes, ditchers, etc., was put into service; but on roads where such equipment was not available the resort to building up piles by dumping from cars, lifting and shifting the track, has undoubtedly been responsible for some of the fires.

Once a pile of coal takes fire, about the only remedy is to put in steam shovels, load it up and distribute it as quickly as possible. Throwing water on the pile with hose is not a successful method of fighting fire in such places; in some cases it has seemed to make the fire burn all the more fiercely. Coal burned into a semi-coke condition is, of course, damaged, but, in order to prevent entire loss, it is steam-shoveled into steel gondola cars and run under standpipes or spouts at water tanks, where the fire is readily quenched by filling the cars and drowning it out.

Storage of coal under water is the ideal method, as deterioration from weather is prevented, and, of course, the danger from fire is entirely overcome. The digging and lining of storage pits is, of course, an expensive matter, but many railroads have old gravel, stone quarry or other pits available that are, or could be, flooded, and such offer a good opportunity for safe storage of coal at but little cost. In other situations there are streams with hard bottom in ravines or narrow valleys that could be utilized for coal storage by damming and flooding, and in some cases the water could be let off at will, making it possible to shovel the coal up from a dry pile, instead of dredging it from under water, although the latter method is entirely practicable and not expensive.—*Railway Review.*

Storage of Coal

THE British Fire Prevention Committee, have issued a series of suggestions for precautions to be taken when coal is stored in bulk. To guard against spontaneous combustion the stacks should not be higher than 10 feet; iron pipes 3 inches or 4 inches in diameter, or, failing these, earthenware pipes or ducts formed of incombustible material, should be inserted vertically in the stacks as they are built up, their lower ends being at different heights above the ground throughout the stacks, with about one pipe or duct to every 300 square foot of surface; a thermometer should be occasionally lowered down these pipes or ducts to ascertain the temperature from the center of the stack; and if wet, very small, soft or impure coal is received it should be dumped round the edges of the stack, or in some position where the air can get to it freely and where other coal will not be packed on top of it.

Features of Locomotive Design

IN looking over the field of international locomotive engineering it is interesting to note the sources of a few of the fundamental features that have been almost universally adopted. The various wheel arrangements, such as the "Atlantic," "Pacific" etc., are derived from American practice. The valve gear, Walschaerts, is Belgian. The bogieis Italian, Cartazzi, while the superheater is German, Schmidt.

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